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PART I

**Bioventing Pilot Test Work Plan for
Buildings 110 and 241
Former Heating Oil and Gasoline UST Sites
Los Angeles AFB, California**

PART II

**Draft Bioventing Pilot Test Interim Results Report
for Building 241, Gate 3, and Building 125
Former Heating Oil UST Sites
Los Angeles AFB, California**

Prepared For

**Air Force Center for Environmental Excellence
Brooks AFB, Texas**

and

Los Angeles AFB, California

ES

Engineering-Science, Inc.

January 1994

9404 Genesee Avenue, Suite 140
La Jolla, California 92037

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PART I

**BIOVENTING PILOT TEST WORK PLAN FOR
BUILDINGS 110 AND 241
FORMER HEATING OIL AND GASOLINE UST SITES
LOS ANGELES AFB, CALIFORNIA**

and

PART II

**DRAFT BIOVENTING PILOT TEST INTERIM RESULTS REPORT
FOR
BUILDING 241, GATE 3, AND BUILDING 125
FORMER HEATING OIL UST SITES
LOS ANGELES AFB, CALIFORNIA**

Prepared for

Air Force Center for Environmental Excellence

Brooks AFB, Texas

and

Los Angeles AFB, California

January 1994

**Engineering-Science, Inc.
9404 Genesee Avenue, Suite 140
La Jolla, California 92037**

PART I

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PART I

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PART I

BIOVENTING PILOT TEST WORK PLAN FOR BUILDINGS 110 AND 241 FORMER HEATING OIL AND GASOLINE UST SITES AT LOS ANGELES AFB, CALIFORNIA

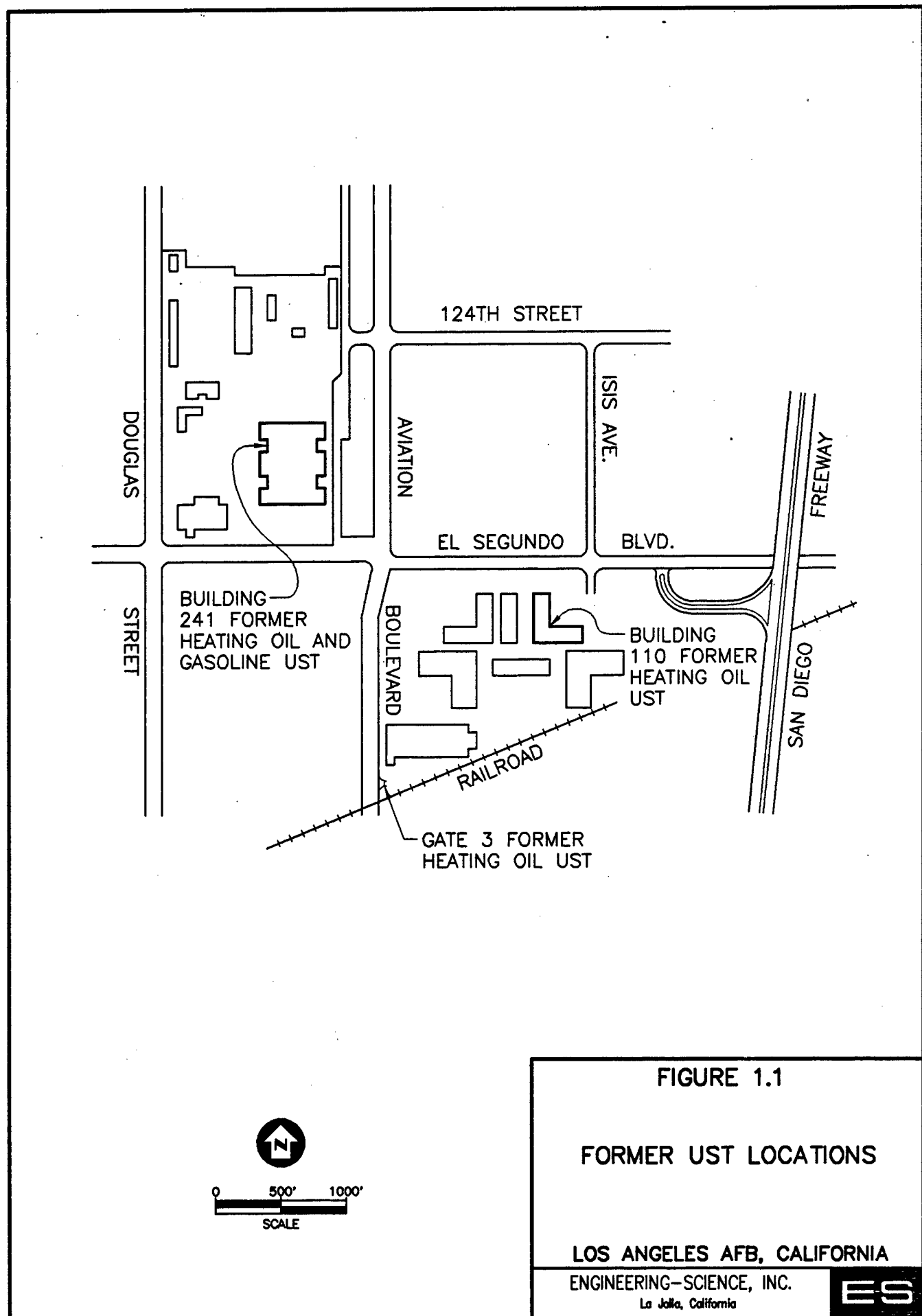
1.0 INTRODUCTION

This Pilot Test Work Plan presents the scope of three *in situ* bioventing pilot tests for the treatment of fuel-contaminated soils at two former heating oil underground storage tank (UST) areas and one former gasoline UST area. The three UST areas are the Building 110 former heating oil UST, the Building 241 former heating oil UST, and the Building 241 former gasoline UST, all located at Los Angeles Air Force Base (AFB) in California (Figure 1.1). Los Angeles AFB is located in El Segundo in Los Angeles County, approximately two miles south of Los Angeles International Airport. Background information in this Pilot Test Work Plan regarding the Building 110 former heating oil UST site and the Building 241 former heating oil UST site is derived from tank removal soil sampling field notes and results supplied by Los Angeles AFB. Background information on the Building 241 former gasoline UST site is derived from Engineering-Science, Inc.'s (ES) on-site observations of the Mittelhauser Corporation site investigation and from their subsequent UST investigation report (Mittelhauser, October 1992).

In the event that conditions at any of the three previously described sites prove nonconductive to the bioventing process, the Gate 3 former 50,000-gallon heating oil UST site will serve as an alternate site. Background information on this recently excavated UST was derived from conversations with Mr. Michael Hanna, the base point of contact, on 25 May 1993.

Bioventing tests have three primary objectives: (1) to assess the potential for supplying oxygen throughout the contaminated soil interval, (2) to determine the rate at which indigenous microorganisms will degrade fuel in the soil when stimulated by oxygen-rich soil gas, and (3) to evaluate the potential for sustaining these rates of biodegradation until fuel contamination is remediated to concentrations below regulatory standards.

Pilot tests will be conducted in two phases. The initial pilot test phase will include installation of vent wells (VW) and vapor monitoring points (MPs) at each site, followed by *in situ* respiration tests and air permeability tests. The initial pilot test will determine important design parameters such as air permeability, radius of influence, biodegradation rates, and potential air emission quantities. It is anticipated that the duration of this initial testing will be approximately four weeks. If initial testing



proves successful, an extended (one-year) testing phase will be initiated which will determine the longer term application of this remedial technology to degrade hydrocarbons at each individual site.

If bioventing is determined to be feasible at these sites, pilot test data could be used to design and implement remediation systems and to estimate the time required for site cleanup. Since testing will take place within the most contaminated soils at each site, an added benefit of the pilot testing at the former UST areas of Buildings 110 and 241 is that a significant amount of the fuel contamination should be biodegraded during the extended (one-year) pilot tests.

Additional background information on the development and recent success of bioventing technology is found in the *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Hinchee, et al., 1992). This protocol document will also serve as the primary reference for pilot test well designs and the detailed procedures which will be used during the tests.

2.0 SITE DESCRIPTION

2.1 Building 110 Former Heating Oil UST Site

2.1.1 Site Location and History

Building 110 is located southwest of the intersection of El Segundo Boulevard and Isis Avenue. The former UST location, with respect to Building 110, is shown in Figures 1.1 and 2.1. Building 110 contains various administrative offices. The facility is currently active. The area surrounding Building 110 is paved with asphalt.

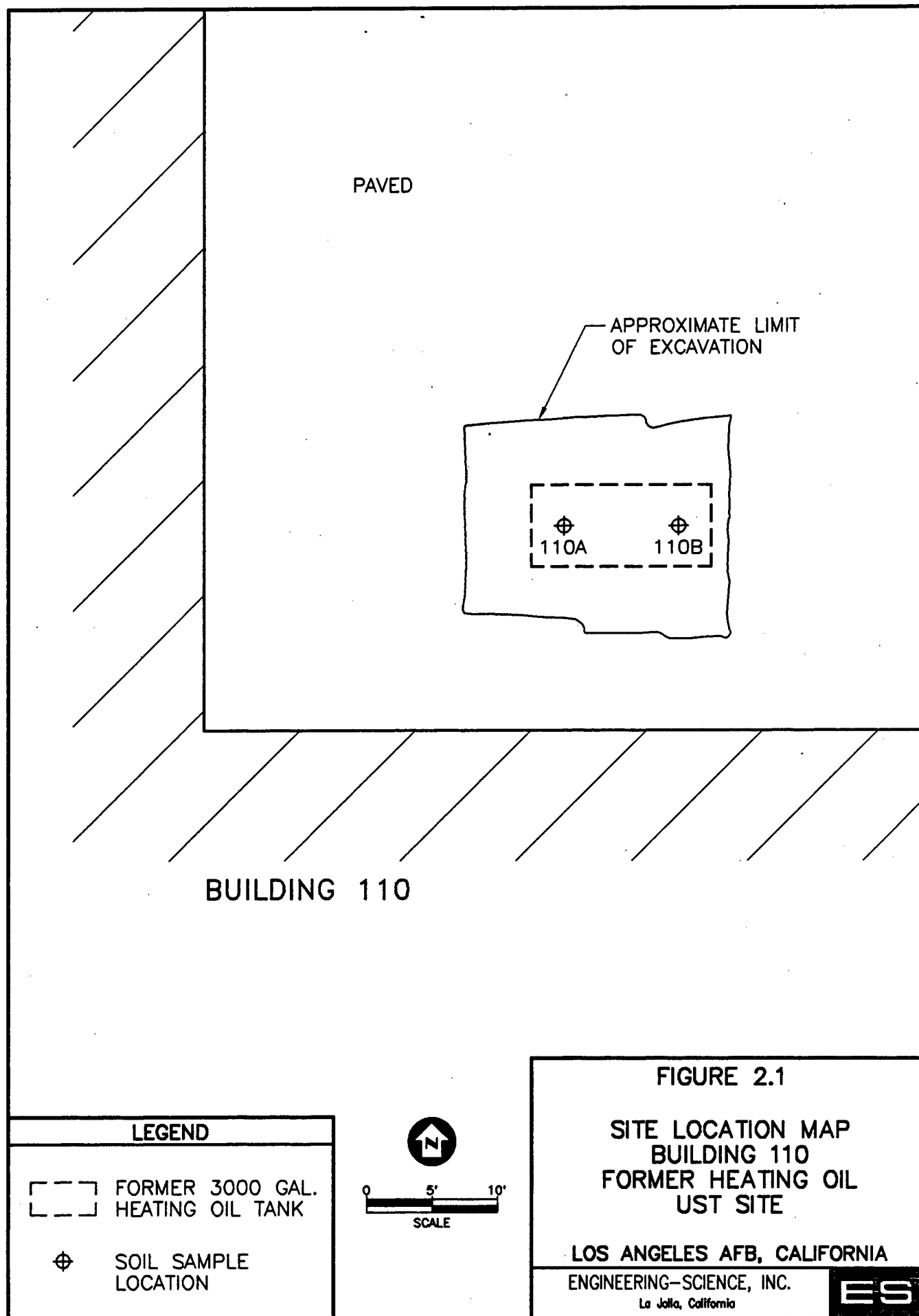
The former 3,000 gallon heating oil tank was reportedly installed in the mid-1950s before the facility was under U.S. Air Force control. The single-walled steel tank was used to store back-up fuel for heating.

The tank was removed on January 26, 1993. Backfill and native material consisted of fine to coarse sand and silty sand. Available field notes did not indicate whether backfill or soil from the tank excavation appeared contaminated. A clay layer was encountered at the excavation bottom, approximately nine feet below ground surface (bgs). Approximately two feet of apparently perched groundwater accumulated in the excavation following tank removal. A portion of a concrete slab of unknown dimension was encountered on the north side of the excavation bottom. Two soil samples were collected from the excavation bottom. One additional soil sample was collected from the excavated backfill material. The contaminated material was returned to the tank bed following tank removal. The remainder of the excavation was filled with clean fill material and the surface was repaved with asphalt.

2.1.2 Site Geology

Los Angeles Air Force Base is located in an area of recently active and stabilized dune sands known as the El Segundo Sand Hills. These dune sediments are of Pleistocene and Recent age. Depth to groundwater at the base is reported to be approximately 50 to 60 feet bgs.

Specific geologic information for the area adjacent to Building 110 is limited to observations made during tank removal. Native material consists of fine to coarse sand



from just below ground surface to approximately nine feet bgs. Clay was encountered at nine feet bgs, the excavation bottom. The clay is apparently impermeable and somewhat laterally extensive, as perched groundwater was encountered above the clay. It is not known how thick the clay is or how deep heating oil contamination extends into the clay.

2.1.3 Site Contaminants

The primary contaminants documented at the site are petroleum hydrocarbons in the diesel range (TPH-d). Three soil samples were collected during tank removal. Locations of samples 110A and 110B are shown on Figure 2.1. Both samples were collected from approximately nine feet bgs. Sample 110 SPI (not shown on Figure 2.1) was collected from the excavated backfill soil pile which has subsequently been returned to the excavation. Analytical results from these samples are as follows:

Sample ID	EPA 8015 in mg/kg (TPH-d)	EPA 418.1 in mg/kg (TRPH)	EPA 8020 - in ug/kg				
			Benzene	Toluene	Chloro- Benzene	Ethyl Benzene	Xylenes
110A	22,000	22,000	ND	50	ND	95	910
110B	41	26	ND	ND	ND	ND	ND
110 SPI	29	30	ND	ND	ND	ND	ND

There are currently no groundwater monitoring wells in the area. Heating oil contamination impact in the locally perched groundwater is suspected but not confirmed.

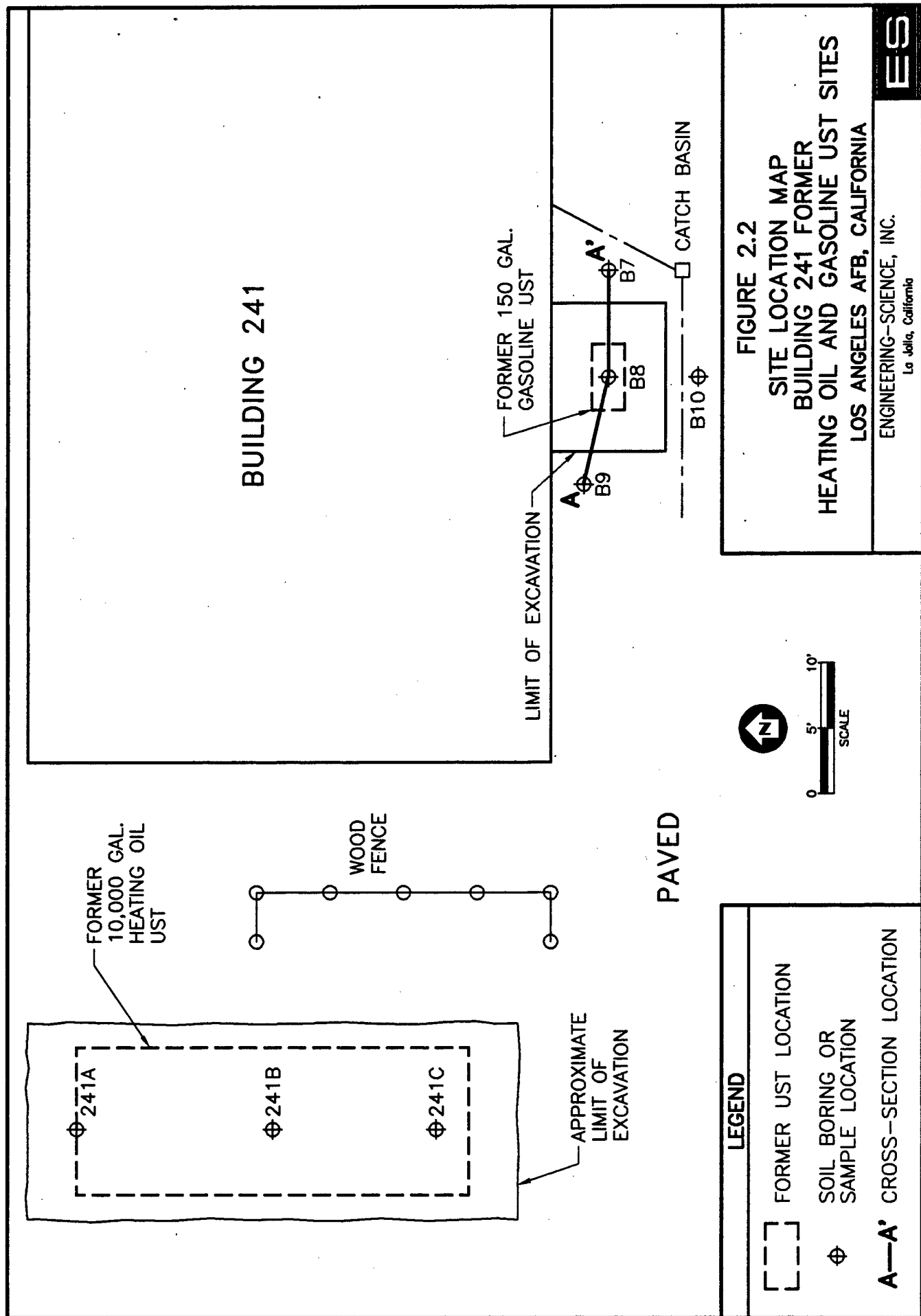
2.2 Building 241 Former Heating Oil UST Site

2.2.1 Site Location and History

Building 241 is located between Douglas Street and Aviation Boulevard. The former heating oil UST location, with respect to Building 241, is shown in Figures 1.1 and 2.2. The western section of Building 241 houses a boiler facility. The facility is currently active. The area surrounding the building is paved with asphalt and concrete.

The former 10,000 gallon heating oil tank was reportedly installed in the mid-1950s, before the facility was under U.S. Air Force control. The former single-walled steel tank was used to store back-up fuel for heating.

The tank was removed in late January 1993. Available field notes do not describe the nature of the backfill material. Native material at the excavation bottom, approximately 15 feet bgs, bottom consists of black silty clay. A very strong diesel odor was observed in this material. Three soil samples were collected from approximately two feet below the excavation bottom. One additional soil sample was collected from the excavated backfill material. The contaminated material was returned to the tank bed following tank removal. The remainder of the excavation was filled with clean fill material and the surface was repaved with asphalt.



2.2.2 Site Geology

Few geologic observations were made during tank removal activities. Field notes referred to a silty clay at the tank excavation bottom.

The former heating oil tank was located approximately 65 feet northwest of the former gasoline tank, for which additional geologic information is available (see Subsection 2.3.2). Assuming the geologic conditions are similar, a silty clay extends from beneath the pavement to approximately 10 to 15 feet bgs. A fine- to medium-grained sand extends from approximately 15 to 35 feet bgs. Clay extends from 35 feet bgs to at least 40 feet bgs, at which depth the deepest boring in the area of the former gasoline tank was terminated.

2.2.3 Site Contaminants

The primary contaminants documented at the site are petroleum hydrocarbons in the diesel range (TPH-d). Four soil samples were collected during tank removal. Locations of samples 241A, 241B, and 241C are shown on Figure 2.2. These samples were collected from approximately two feet below the excavation bottom, approximately 17 feet bgs. Sample 241 SPI (not shown on Figure 2.2) was collected from the excavated backfill soil pile which has subsequently been returned to the excavation. Analytical results from these samples are as follows:

Sample ID	EPA 8015 in mg/kg (TPH-d)	EPA 418.1 in mg/kg (TRPH)	EPA 8020 - in ug/kg				
			Benzene	Toluene	Chloro- Benzene	Ethyl Benzene	Xylenes
241A	7,500	7,000	ND	ND	ND	72	56
241B	8,800	6,000	ND	ND	ND	87	65
241C	9,200	7,400	ND	1.1	ND	120	88
241 SPI	32	70	ND	ND	ND	ND	ND

There are currently no groundwater monitoring wells in the area.

2.3 Building 241 Former Gasoline UST Site

2.3.1 Site Location and History

The location and history of Building 241 are described in Subsection 2.2.1. The former gasoline UST location, with respect to Building 241, is shown in Figures 1.1 and 2.2.

It is unknown but assumed that the former 150 gallon UST was installed in the mid-1950s. The gasoline tank was removed in August 1990 by Tetra Tech, Inc. A soil sample collected during tank removal documented contamination by total recoverable petroleum hydrocarbons (TRPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX).

In July 1992, additional site characterization work was performed by Mittelhauser Corporation (Mittelhauser). Four soil borings were drilled and sampled. Results of the Mittelhauser investigation are detailed in the October 1992 "UST Investigation Report, Los Angeles Air Force Base" (Mittelhauser Corporation, 1992).

2.3.2 Site Geology

Site geologic information was obtained from the four soil borings drilled by Mittelhauser. Figure 2.2 shows the locations of the Mittelhauser borings. Figure 2.3 is a cross-section constructed from soil boring logs. It shows the profile from ground surface to approximately 41 feet bgs. As described in Subsection 2.2.2, soils of the upper 10 to 12 feet are predominantly clay and silty clay. Fine to medium sand is encountered here, to approximately 35 feet bgs. A clay was encountered from 35 to 41 feet bgs, at which depth the deepest boring, B-9, was terminated. The lateral extent of this clay is unknown. Groundwater at the site was not encountered in the Mittelhauser borings, but it is anticipated at 50 to 60 feet bgs. No groundwater wells have been installed near this site.

2.3.3 Site Contaminants

The primary contaminants documented at the site are petroleum hydrocarbons in the gasoline range (TPH-g) and the associated BTEX components. A sample collected during the 1990 tank removal operation had a TRPH concentration of 760 mg/kg. BTEX concentrations in excess of 6 mg/kg were also detected. Information such as sample depth, location, specific compound and concentration, etc., was not found in readily available site information supplied by the base.

Location of soil samples collected during the Mittelhauser investigation are shown in Figure 2.3.

The sample at six feet bgs from Boring B-8 had the following results:

Sample ID	8015 M-Gas in mg/kg (TPH-g)	EPA 8020 - in ug/kg			
		Benzene	Toluene	Ethyl Benzene	Xylenes
B-8-6'	1850	6.24	31.8	18.7	91.4

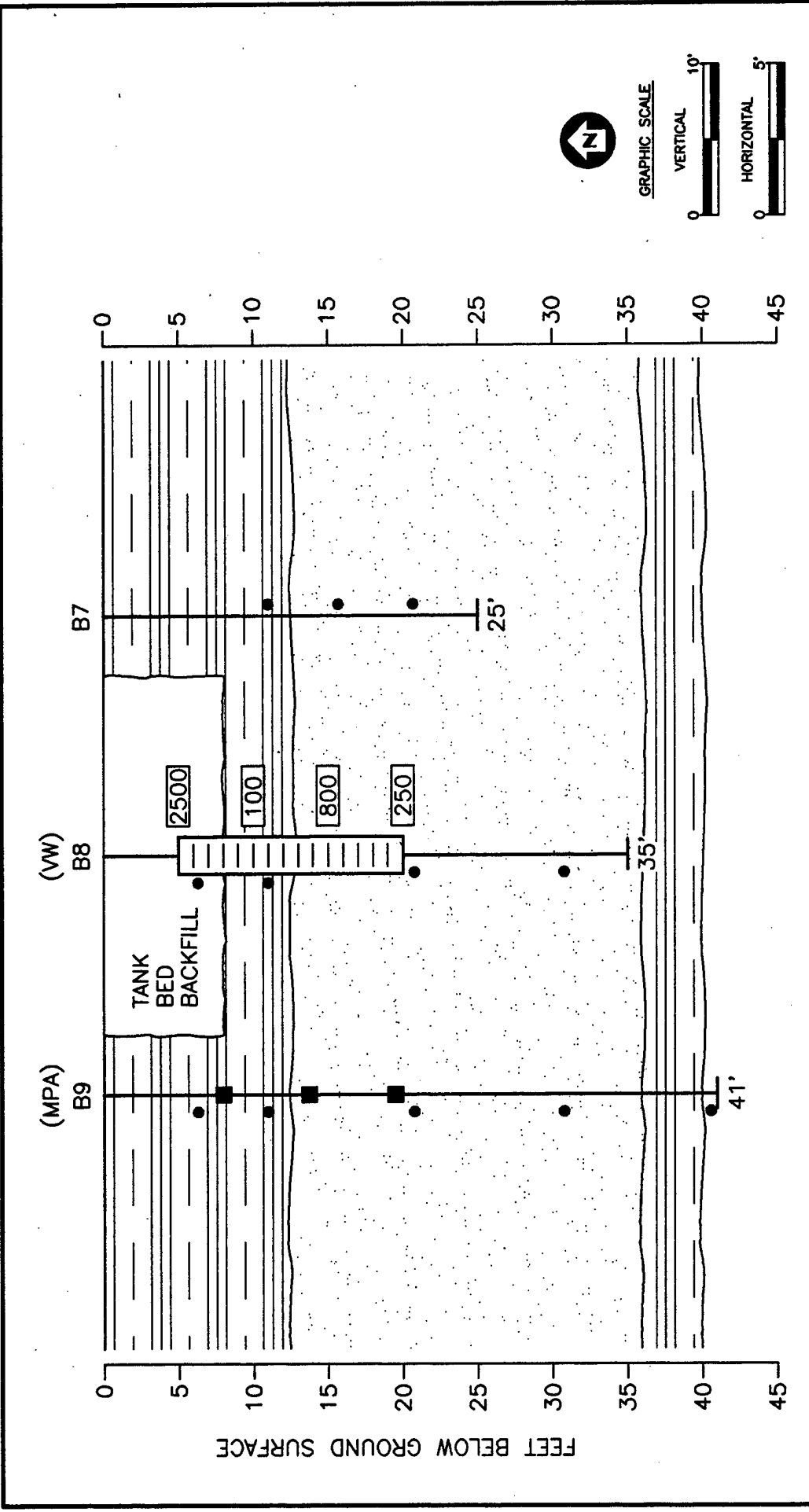
No gasoline (EPA 8015 Modified, with detection limit of 1 mg/kg) or BTEX (EPA 8020, with detection limit of 5 ug/kg) was detected in the other soil samples collected by Mittelhauser from Borings B-7 through B-10. However, the samples from 11 feet, 16 feet, and 21 feet bgs in Boring B-8 had soil sample headspace photoionization detector (PID) readings of 100, 800, and 250 ppm, respectively.

2.4 Alternate Site: Gate 3 Former Heating Oil UST Site

2.4.1 Site Location and History

In the event that one of the preceding sites does not have low initial soil gas oxygen concentrations, a pilot test will be conducted at the Gate 3 former heating oil UST site. Gate 3 is located east of Aviation Boulevard, immediately north of the railroad tracks (Figure 1.1). The approximate former UST location, with respect to Gate 3, is shown in Figure 2.4.

The former 50,000-gallon single-walled fiberglass tank was installed in the 1970s for emergency heating oil storage. Approximately 25,000 gallons of heating oil are reported to have leaked from this tank. The surrounding area is paved with asphalt.



LEGEND

- SOIL SAMPLE LOCATIONS
- ▢ SAND
- ▢ 2500 FIELD PID READING
- ▢ CLAY/SILTY CLAY
- ⊥ B9 41' SOIL BORING LOCATION AND TOTAL DEPTH
- MONITORING POINT INSTALLED DURING MITTLEHAUSER INVEST.
- ▤ SCREENED INTERVAL INSTALLED DURING MITTLEHAUSER INVEST.

FIGURE 2.3

GEOLOGIC CROSS-SECTION A-A'

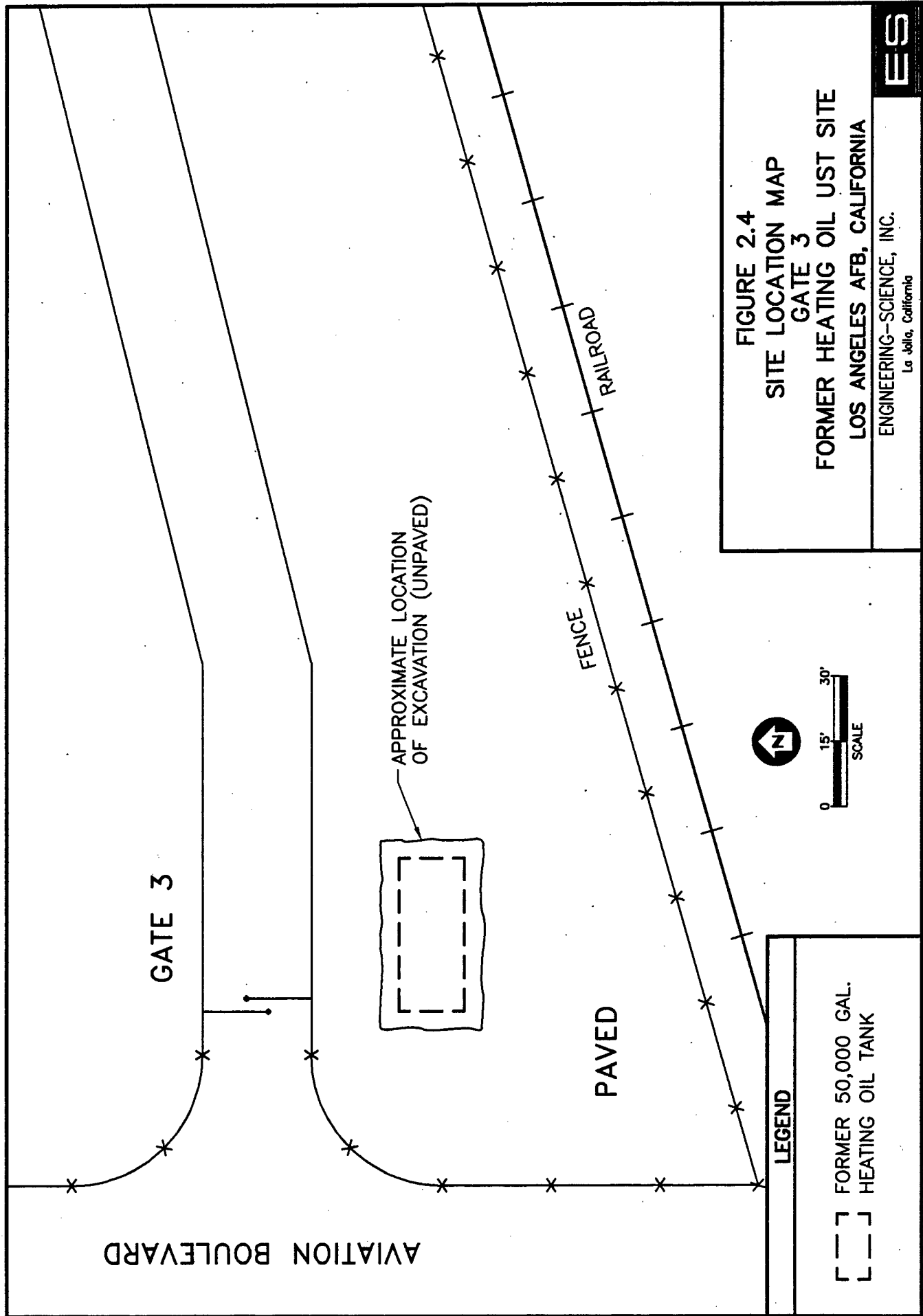
BUILDING 241

FORMER GASOLINE UST SITE

LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
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The tank was removed in April 1993. Only verbal results of tank removal activities were available at the time of this writing. Evidence of contaminated soil was observed in the tank bed, especially toward the west end of the excavation. Two soil samples were collected from the excavation bottom, which was estimated to be 15 feet to 20 feet bgs. The contaminated backfill material was returned to the excavation. The remainder of the excavation was filled with clean backfill. The excavation surface remains unpaved. The surrounding area is paved with asphalt.

2.4.2 Site Geology

Field observation notes were unavailable at the time of this writing. It is presumed that site geology is similar to that encountered near Building 241 (see Subsection 2.3.2).

2.4.3 Site Contaminants

The primary contaminants reported to have been found at the site are petroleum hydrocarbons in the diesel range (TPH-d).

At least two soil samples were collected during tank removal operations. The samples were collected at two and five feet below the tank bed. Analytical results, as reported by the base point of contact, Mr. Michael Hanna, were 6,640 mg/kg TPH-d and 3,350 mg/kg TPH-d, respectively, as detected by EPA Method 8015 Modified for fuel oil.

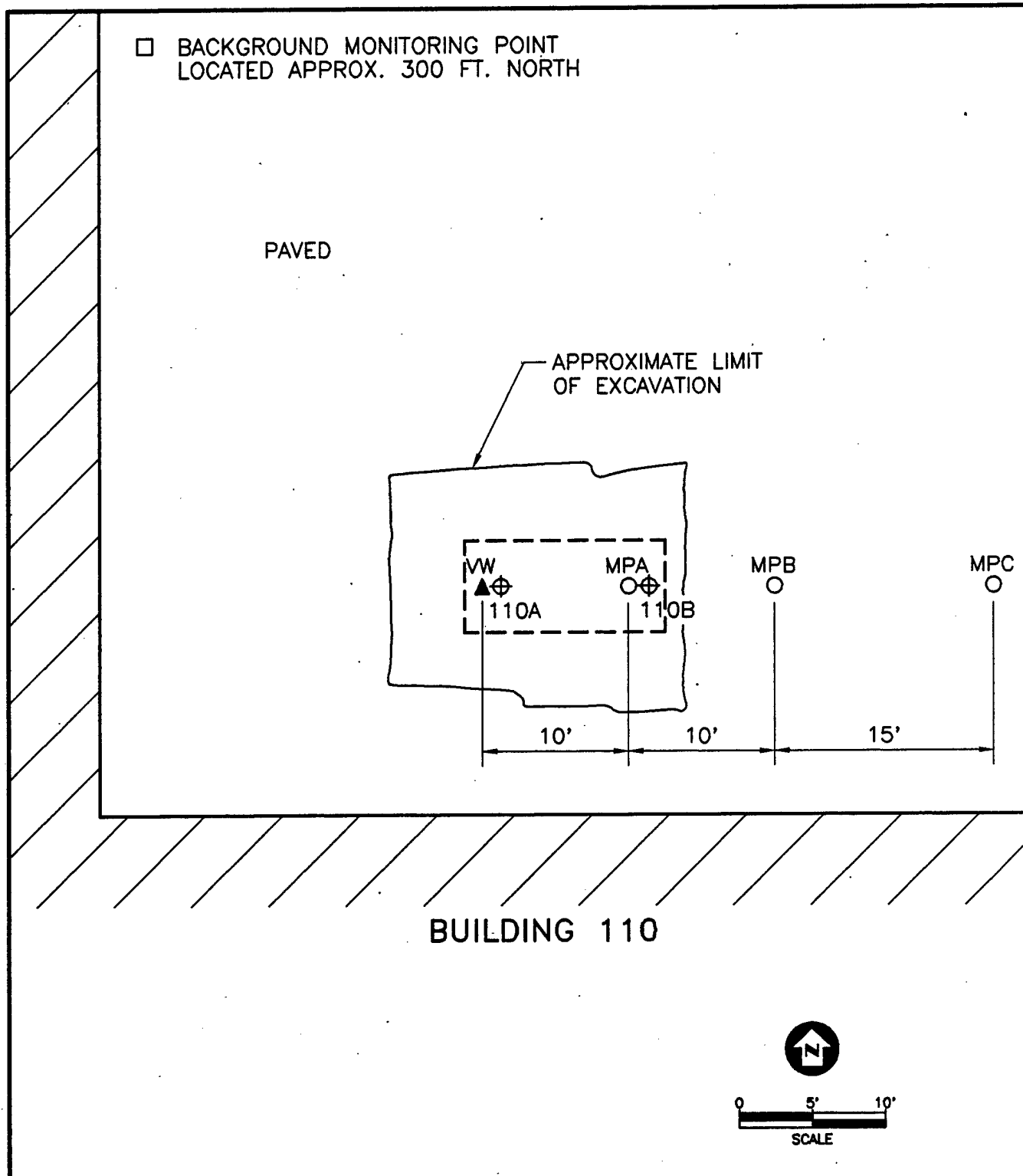
3.0 SITE-SPECIFIC ACTIVITIES

The purpose of this section is to describe the bioventing test that will be performed by Engineering-Science, Inc., at the three UST sites. Activities at each site will include: (1) siting and construction of a central air injection well, or VW, and three vapor MPs (at the heating oil UST sites only); (2) an air permeability test; (3) an *in situ* respiration test; and (4) the implementation of an extended (one-year) bioventing pilot test. Soil and soil gas sampling procedures are described below. In addition, the blower configurations that will be used to inject air (oxygen) into contaminated soils through the VWs are also discussed in this section. No dewatering or groundwater treatment will take place during the pilot tests. Pilot test activities will be confined to the remediation of unsaturated soils.

3.1 Location and Construction of Vent Wells and Vapor Monitoring Points

3.1.1 Building 110 Former Heating Oil UST Site

A general description of criteria used for siting a central VW and MPs are included in the protocol document (Hinchee et al., 1992). Figure 3.1 indicates the proposed locations of the central VW and MPs at this site. The final locations of the VW and MPs may vary slightly from the proposed locations if significant fuel contamination is not observed in the boring for the central VW. Based on tank bed soil sampling data, the central VW should be located in the area of highest detected fuel contamination. This area is expected to have an average TPH concentration exceeding 20,000 mg/kg. Soils in this area are expected to be oxygen-depleted (<2 percent O₂), and increased biological activity should be stimulated by oxygen-rich soil gas ventilation during both the initial and extended pilot tests.



LEGEND

- FORMER 3000 GAL.
HEATING OIL UST LOCATION
- ⊕ SOIL SAMPLE LOCATION
- ▲ VENT WELL
- MONITORING POINT
- BACKGROUND MONITORING POINT

FIGURE 3.1

PROPOSED VENT WELL/VAPOR
MONITORING POINT LOCATIONS
BUILDING 110
FORMER HEATING OIL UST

LOS ANGELES AFB, CALIFORNIA

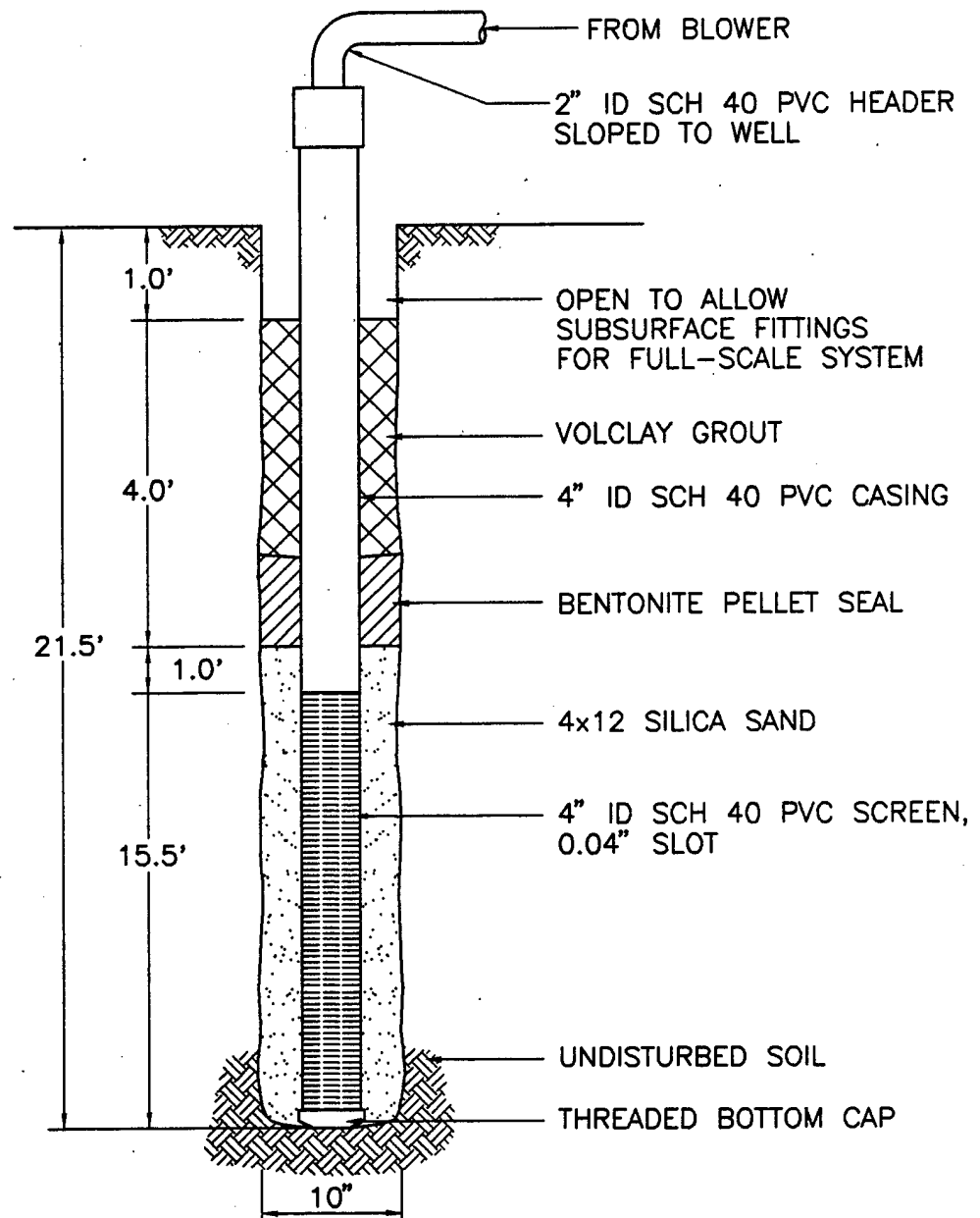
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ES

The extent of soil contamination is not known. It is possible that contaminants may not have migrated substantially from the former tank bed. Therefore, the radius of influence of the VW may be greater than the extent of soil contamination. The radius of venting influence around the central VW is estimated to be 40 to 50 feet based on the composition of the soil at the site. Three MPs will be located within a 35-foot radius of the central VW, in contaminated soil if possible. A fourth MP will be located approximately 300 feet north of the central VW. This background MP will be used to measure background levels of oxygen and carbon dioxide at the base and to determine whether inorganic or natural carbon sources are contributing to oxygen uptake during the *in situ* respiration test. Additional details of the *in situ* respiration test are found in Section 5.7 of the protocol document (Hinchee et al., 1992).

Figure 3.2 is a central VW construction diagram for this site. The central VW will be constructed of four-inch ID Schedule 40 PVC, with an interval of 0.04-inch slotted screen set at a depth of approximately six feet bgs or at the top of the contaminated soil interval. The screen will extend to the base of contamination as determined by field organic vapor analysis (OVA) of soil samples. A 100 ppmv (parts per million by volume) OVA reading will be the criterion used in determining the depth selected as the base of contamination. A GasTech™ Total Hydrocarbon Vapor Analyzer (THVA) will be used to collect field OVA readings. This platinum catalyst combustion detector is calibrated with hexane, which provides a conservative reading representative of TPH vapors present. Flush-threaded PVC casing and screen will be installed without using organic solvents or glues. The filter pack will consist of clean, 8-12 grain size silica sand or equivalent, and will be placed in the annular space of the screened interval. A two-foot-thick layer of bentonite pellets, hydrated in place with potable water, will be placed directly over the filter pack. This layer will prevent the Volclay® grout slurry from saturating the filter pack. The Volclay® grout will be tremied into the annular space above the bentonite pellets to a depth of one foot bgs, thus producing an air-tight seal above the screened interval. A complete seal is critical to prevent injected air from short-circuiting to the surface during the bioventing test.

A typical, multi-depth MP installation for this site is shown in Figure 3.3. Oxygen and carbon dioxide soil gas concentrations will be monitored via vapor monitoring screens placed at depth intervals of 10 feet, 15 feet, and 20 feet bgs depending on the extent of contamination as determined by the field OVA readings at each location. If the base of contamination is determined to be below 20 feet, the vapor monitoring screen depths may be altered to provide better vertical coverage for soil gas monitoring (e.g., 10 feet, 20 feet, 30 feet). Multi-depth monitoring will assess whether the entire soil profile is receiving oxygen and will be used to measure fuel biodegradation rates at all monitored depths. The annular space between the vapor monitoring screen filter packs will be sealed with Volclay® grout to isolate the monitoring intervals. As with the central VW, several inches of bentonite pellets will be used directly above and below the filter pack intervals for seals. In the vapor monitoring point closest to the VW (MPA), thermocouples will be installed at the deepest and shallowest vapor monitoring screens to measure soil temperatures. Additional details on VW and MP construction are found in Section 4.0 of the protocol document (Hinchee et al., 1992).



NOT TO SCALE

NOTE: SCREENED INTERVAL TO BE DETERMINED DURING INSTALLATION.

FIGURE 3.2
PROPOSED AIR INJECTION VENT
WELL CONSTRUCTION DETAILS
BUILDINGS 110 AND 241 FORMER
HEATING OIL UST SITES

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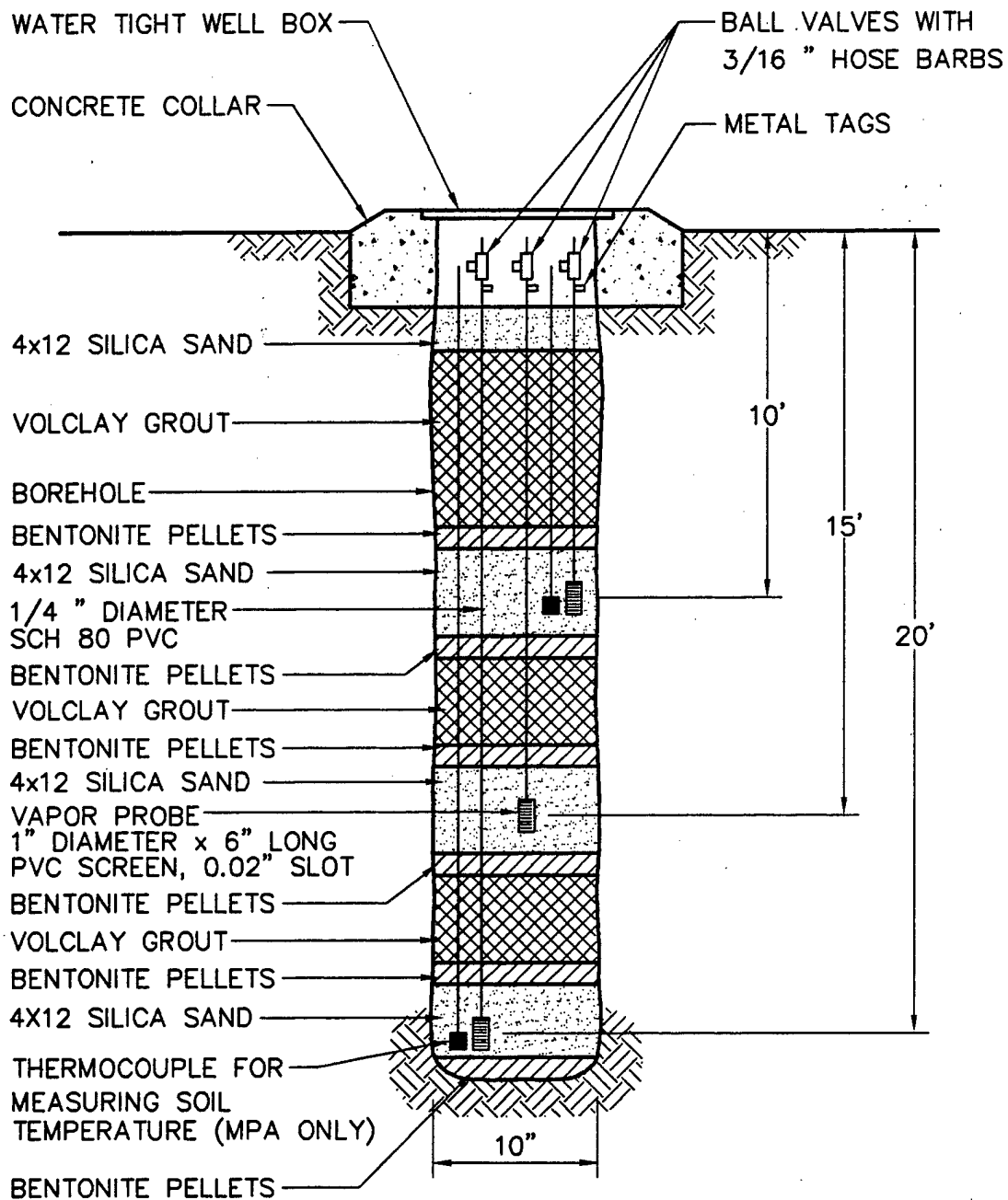


FIGURE 3.3

PROPOSED MONITORING POINT
CONSTRUCTION DETAILS
BUILDINGS 110 AND 241 FORMER
HEATING OIL UST SITES

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3.1.2 Building 241 Former Heating Oil UST Site

A general description of criteria used for siting a central VW and MPs is included in the protocol document (Hinchee et al., 1992). Figure 3.4 indicates the proposed locations of the central VW and MPs at this site. The final location of the VW and MPs may vary slightly from the proposed location if significant fuel contamination is not observed in the boring for the central VW. Based on site investigation data, the central VW should be located near the center of the former tank bed. This area is expected to have an average TPH concentration exceeding 8,000 mg/kg. Soils in this area are expected to be oxygen-depleted (<2 percent O_2), and increased biological activity should be stimulated by oxygen-rich soil gas ventilation during both initial and extended pilot tests.

The extent of soil contamination is not known. It is possible that contamination may not have migrated substantially from the former tank bed. Therefore, the radius of influence of the VW may be greater than the extent of soil contamination. The radius of venting influence around the central VW is expected to be 40 to 50 feet based on the composition of the soils at the site. Three MPs will be located within a 30-foot radius of the central VW in contaminated soil if possible. MPA at the Building 241 former gasoline UST site will also be monitored during pilot test activities. This point is approximately 55 feet from the central VW.

Figure 3.2 is a central VW construction diagram for this site. Figure 3.3 shows a typical multi-depth MP installation for this site. The central VW and MPs will be constructed as previously described in Subsection 3.1.1.

3.1.3 Building 241 Former Gasoline UST Site

Engineering-Science, Inc., accompanied Mittelhauser in the field during the investigation of this site. Mittelhauser borings B-8 and B-9 were converted into VW and MPA, respectively. The location of VW, MPA, and the other Mittelhauser borings are shown in Figure 3.4. A cross-section of this area showing VW and MPA construction, and the contamination distribution, is shown in Figure 2.3.

Installation of an air injection VW and MPA took place on July 8 and 9, 1992. Drilling services were provided by West Hazmat Drilling Corp. of Anaheim, California. Well installation and soil sampling activities were directed by ES geologist Mr. Larry Dudus.

Mittelhauser boring B-8, drilled through the center of the former tank bed, was the only boring in which contaminated soil was encountered. Therefore, it was converted into the air injection VW. Construction details are shown in Figure 3.5. Boring B-8 was originally drilled to 35 feet bgs. The boring was backfilled to 21 feet bgs with bentonite "Hole Plug". The "Hole Plug" was hydrated with potable water after its emplacement. The well was constructed with two-inch diameter, Schedule 40 polyvinyl chloride (PVC) casing with 15 feet of 0.04-inch slotted PVC screen installed from 5 to 20 feet bgs. The screen bottom was fitted with a 0.25-foot long, threaded cap. The annular space was filled with 8-12 grain size silica sand from the bottom of the borehole to approximately 0.25 feet above the well screen. Approximately 0.9 feet of bentonite pellets was placed above the sand pack and hydrated in place. Approximately three feet of Volclay® grout was emplaced on top of the bentonite

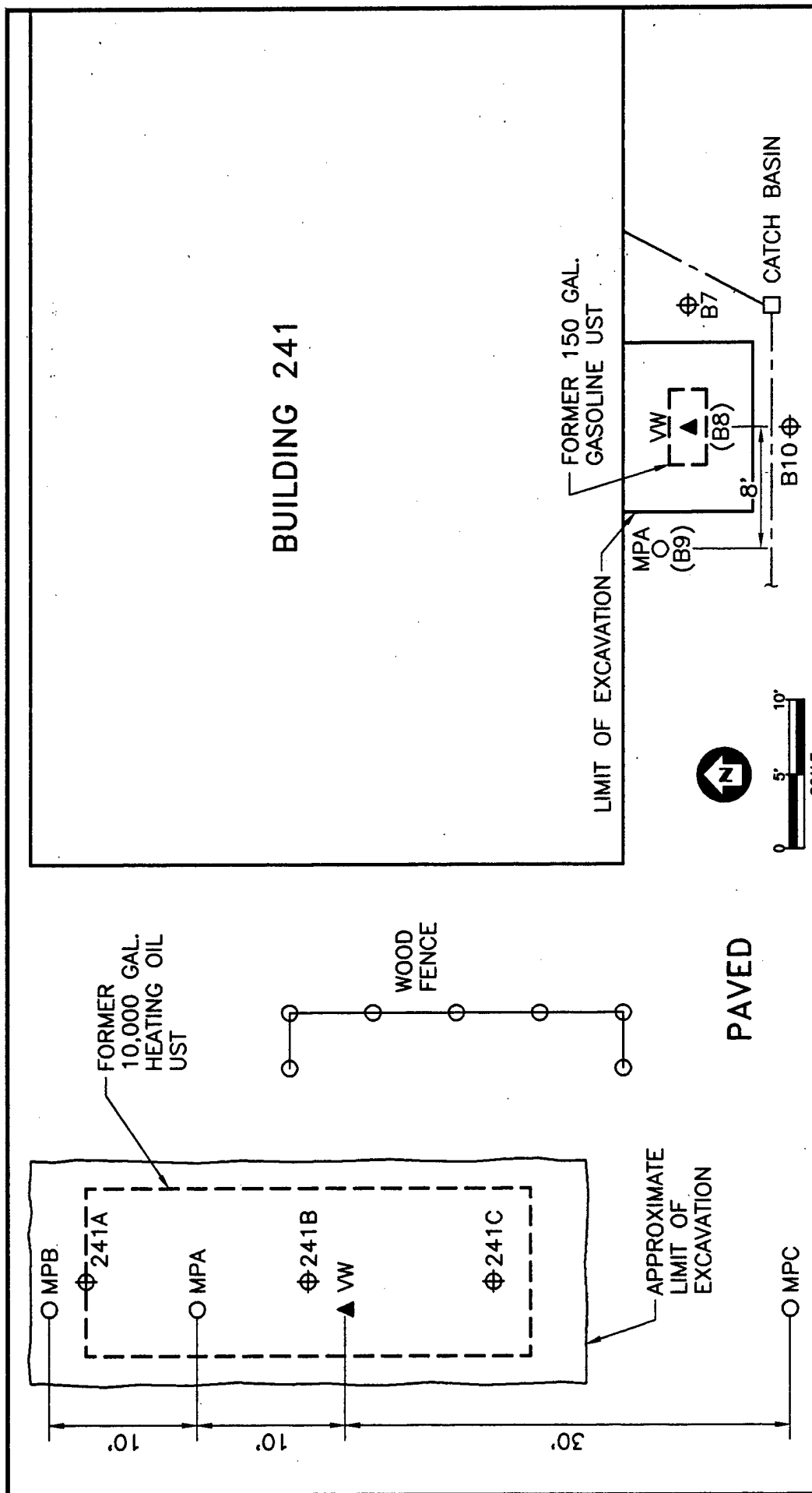


FIGURE 3.4
PROPOSED VENT WELL/MONITORING POINT
LOCATIONS, BUILDING 241 FORMER
HEATING OIL AND GASOLINE UST SITES

LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.

La Jolla, California

SW

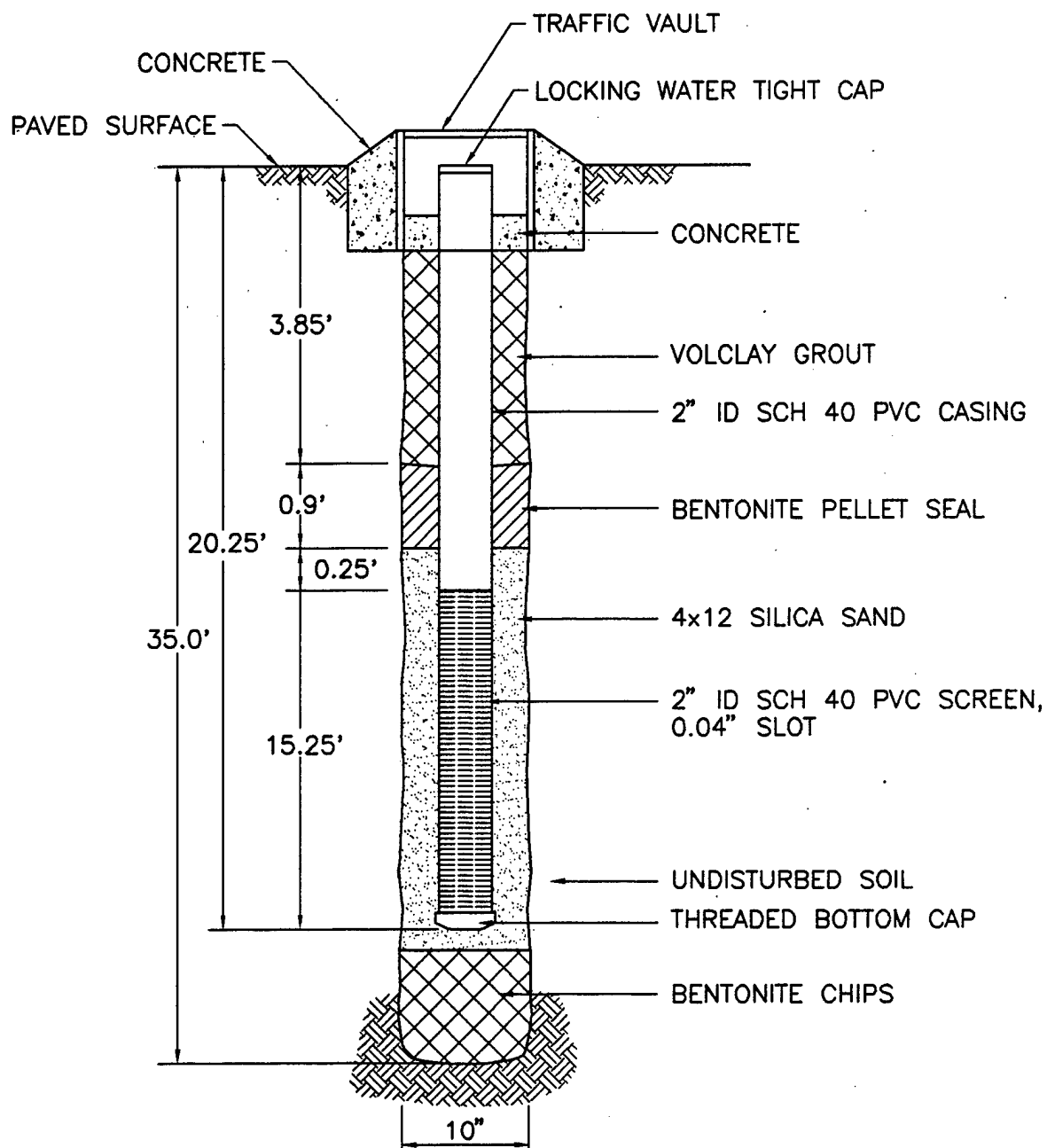
LEGEND

FORMER UST LOCATION

▲ VENT WELL

SOIL BORING OR
SAMPLE LOCATION

O MONITORING POINT



NOT TO SCALE

FIGURE 3.5
RECORD DRAWING
AIR INJECTION VENT WELL
CONSTRUCTION DETAILS
BUILDING 241 FORMER
GASOLINE UST SITE
LOS ANGELES, CALIFORNIA

ENGINEERING-SCIENCE, INC.
 La Jolla, California

ES

pellets. The well was fitted with a locking water-tight cap and flush-finished to the pavement with a traffic vault.

Mittelhauser boring B-9, located eight feet west of VW, was selected as the site's only monitoring point (MPA). The point was located less than two feet away from the former tank bed excavation, yet had no evidence of contamination. Mittelhauser's analytical results confirmed this observation. Construction details for MPA are shown in Figure 3.6.

The MPA screens were installed at depths of 7.6, 13.3, and 19 feet bgs. Each screened interval was constructed using a six-inch section of one-inch diameter PVC well screen and a 0.25-inch-diameter PVC riser pipe extending to the ground surface. At the top of each riser, a ball valve and a 3/16-inch hose barb were installed. The top of MPA was completed with a flush-mounted, metal, well traffic vault set in a concrete base. Thermocouples were not installed in this MP due to the absence of soil contamination. No additional wells are planned for this site.

3.1.4 Alternate Site: Gate 3 Former Heating Oil UST Site

If any of the three previously described sites, particularly the Building 241 former gasoline UST site, proves to be unsuitable for bioventing (i.e., little or no soil contamination, greater than 5% soil gas oxygen concentration), a pilot test will be conducted at the Gate 3 former heating oil UST site.

Proposed locations of the VW and MPs for this alternate site are shown in Figure 3.7. Construction of the VW and MPs will be as previously described in Subsection 3.1.1 and shown in Figures 3.2 and 3.3.

3.2 Handling of Drill Cuttings

Drill cuttings will be collected in U.S. Department of Transportation (DOT) approved containers. These containers will be labeled, then placed in the Los Angeles AFB hazardous materials storage area, or in another area designated by the base point-of-contact. Final disposition of drill cuttings will be the responsibility of Los Angeles AFB, or their designated contractor.

3.3 Soil and Soil Gas Sampling

3.3.1 Soil Samples

Three soil samples will be collected from each pilot test area during the installation of the VWs and MPs (soil samples from the Building 241 former gasoline UST site were previously collected). Sampling procedures will follow those outlined in the protocol document (Hinchee et al., 1992). One sample will be collected from the most contaminated interval of each VW boring. In addition, one sample will be collected from the interval of highest apparent contamination in each of the two MP borings closest to the VW at each site. Soil samples will be analyzed for TRPH, BTEX, soil moisture, pH, grain-size distribution, alkalinity, total iron, and nutrients, including Total Kjeldahl Nitrogen (TKN) and total phosphorous.

An additional soil sample will be collected from representative soils in the background MP and analyzed for TKN in order to characterize the non-contaminated, baseline soil nutrient conditions.

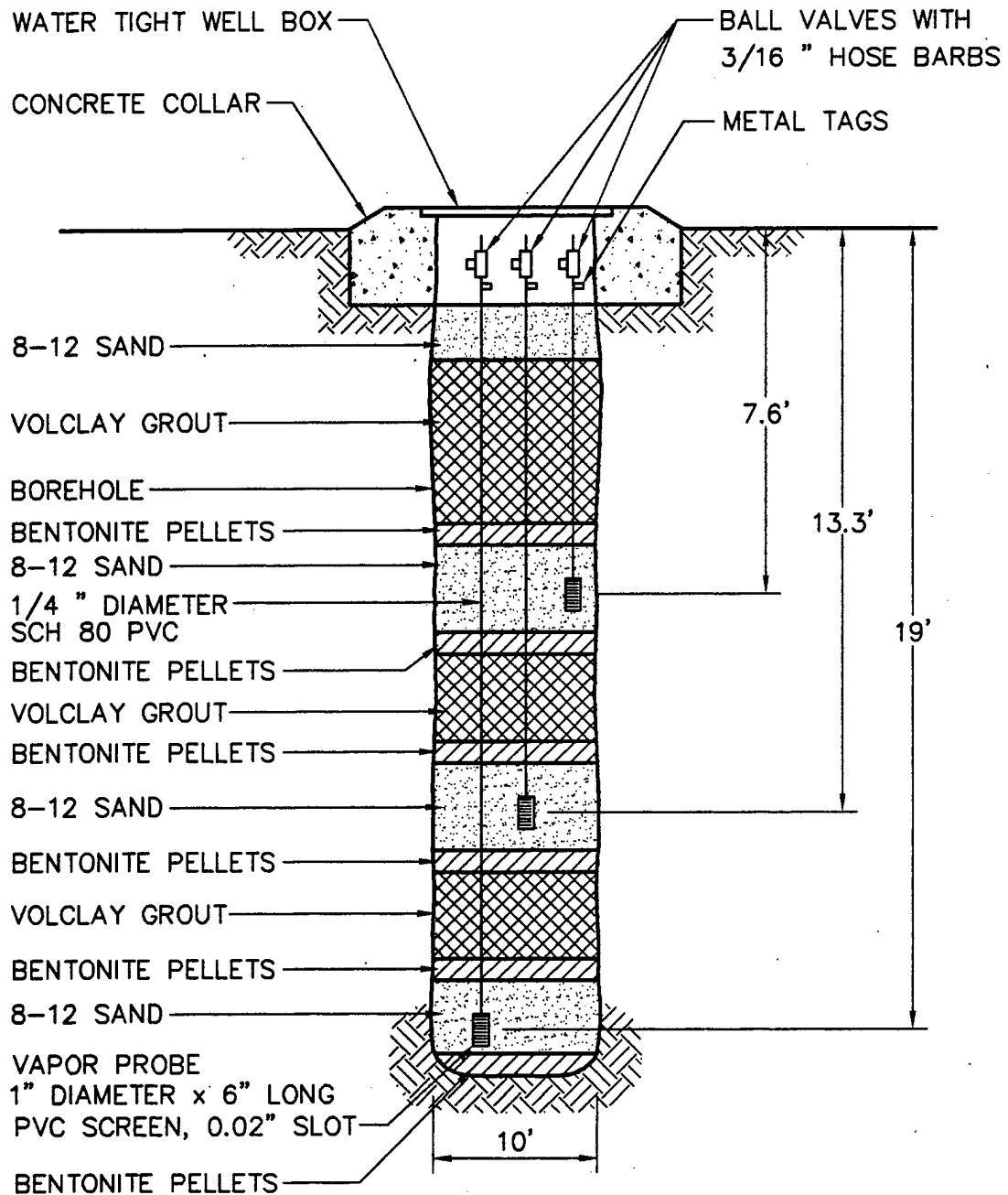


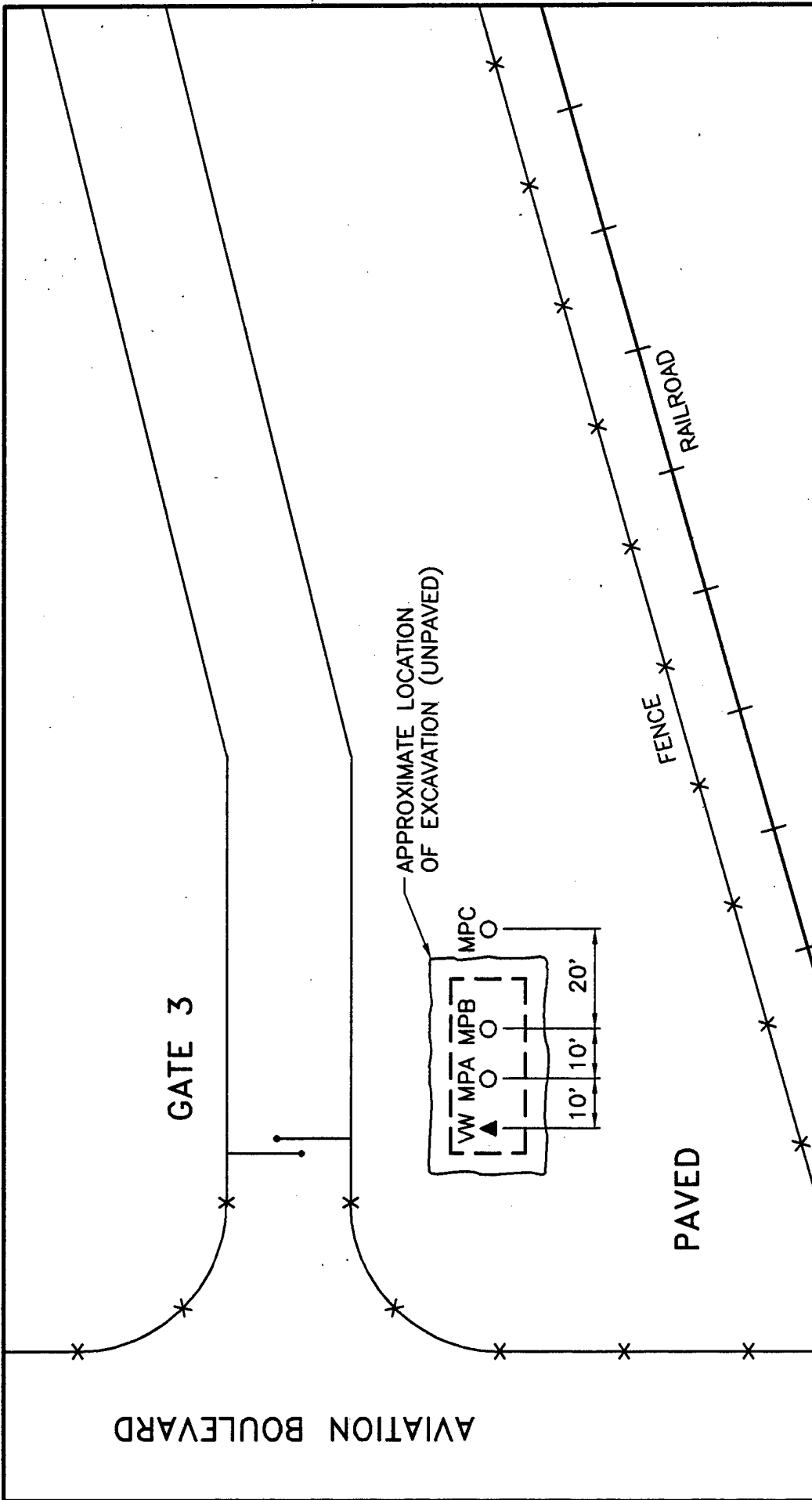
FIGURE 3.6
RECORD DRAWING
MONITORING POINT
CONSTRUCTION DETAILS
BUILDING 241 FORMER
GASOLINE UST SITE

LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.

La Jolla, California

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LEGEND

- [---] FORMER 50,000 GAL. HEATING OIL TANK
- ▲ VENT WELL
- MONITORING POINT

FIGURE 3.7

PROPOSED VENT WELL/MONITORING POINT LOCATIONS, GATE 3 FORMER HEATING OIL UST SITE

LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
La Jolla, California

ES

0 15' 30'
SCALE

Samples for TRPH and BTEX analyses will be collected using a split-spoon sampler containing brass tube liners. Soil samples collected in the brass tubes for TRPH and BTEX analyses will be trimmed immediately, and the ends will be sealed with Teflon sheets and held in place by plastic caps. Soil samples collected for analysis of physical parameters will be placed in glass sample jars, or other appropriate sample containers as specified in the base sample handling plan. Soil samples will be labelled following the nomenclature specified in Section 5.5 of the protocol document (Hinchee et al., 1992), wrapped in plastic, and placed in a cooler for shipment. A chain-of-custody form will be completed, and the cooler will be shipped to Pace Laboratory (formerly ES Laboratory) in Novato, California, for analysis. This laboratory has been audited by the Air Force and meets all Quality Assurance/Quality Control (QA/QC) and certification requirements for the State of California.

3.3.2 Soil Gas Samples

A total hydrocarbon vapor analyzer (THVA) will be used during drilling to screen soil samples for determining intervals of high fuel contamination. During the pilot test, initial soil gas samples will be collected in SUMMA® canisters, in accordance with the Bioventing Field Sampling Plan (ES, 1992). These samples will be collected from VWs, and from the MPs closest to and furthest from the VWs (i.e., MPA and MPC). One soil gas sample from each site, and one soil gas sample from the background MP, will be analyzed to determine the site and background methane concentrations. Additionally, these soil gas samples will be used to predict potential air emissions, to determine the reduction in BTEX and Total Volatile Hydrocarbons (TVH) during the one-year tests, and to detect any migration of these vapors from the source areas.

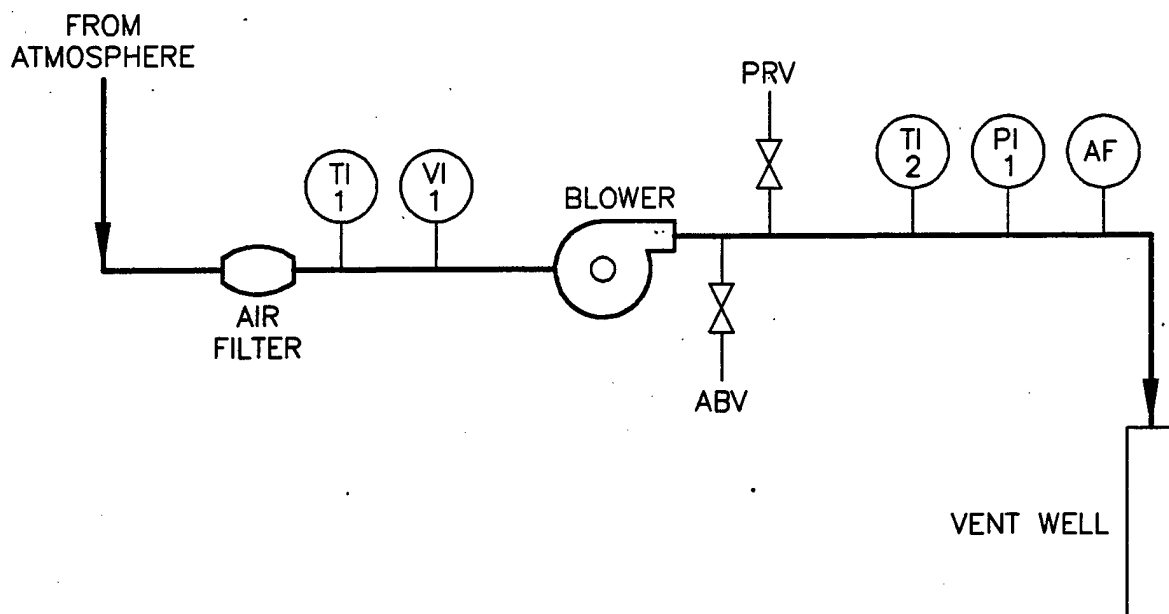
Soil gas sample canisters will be placed in a small cooler and packed with foam pellets to prevent excessive movement during shipment. In order to prevent condensation of hydrocarbons, samples will not be preserved on ice. A chain-of-custody form will be completed, and the cooler will be shipped to the Air Toxics, Inc., laboratory in Rancho Cordova, California, where the samples will be analyzed.

3.4 Blower Systems

A 1-horse-power regenerative blower, capable of injecting 30 standard cubic feet per minute (scfm) at 40 inches of water will be used to conduct the initial air permeability tests at the Building 110 and Building 241 former heating oil UST sites.

A schematic diagram of a typical air injection system used for pilot testing is shown on Figure 3.8. The maximum power requirement anticipated for this pilot test is 230-volt, single-phase, 30-amp service. Additional power supply requirement details are described in Section 5.0, Base Support Requirements.

A small 1 scfm blower will be used for the Building 241 former gasoline UST site. Use of this small blower is warranted because of the small amount of soil contamination at this site. Based on the Mittelhauser site characterization results, contaminated soil lies within an eight-foot radius of the VW. A 1 scfm pump is expected to have sufficient output to effectively oxygenate contaminated soil surrounding the VW. This will be confirmed by an oxygen influence test.



LEGEND

- (AF) AIR FLOW INDICATOR
- (PI 1) PRESSURE INDICATOR
- (TI 1) TEMPERATURE INDICATOR
- (VI 1) VACUUM INDICATOR
- ABV AIR BLEED VALVE
- PRV PRESSURE RELIEF VALVE

FIGURE 3.8
BLOWER SYSTEM
INSTRUMENTATION DIAGRAM
FOR AIR INJECTION
BUILDING 110 AND 241
FORMER HEATING OIL UST SITES
LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
 La Jolla, California

ES

3.5 *In Situ* Respiration Tests

The objective of *in situ* respiration tests is to determine the rate at which soil bacteria degrade petroleum hydrocarbons in the presence of oxygen. Respiration tests will be performed at each site in selected MPs, where bacterial biodegradation of hydrocarbons is indicated by low oxygen levels and elevated carbon dioxide concentrations in the soil gas. A 1 scfm pump will inject air into the selected MP depth intervals containing low oxygen levels ($<2\%$). A 20-hour air injection period will be used to oxygenate local contaminated soils. At the end of the 20-hour air injection period, the air supply will be cut off, and oxygen and carbon dioxide levels will be monitored for the following 48 to 72 hours. The decline in oxygen concentrations and increase in carbon dioxide concentrations over time will be used to estimate rates of bacterial degradation of fuel residuals. Helium, an inert gas, will be injected at a concentration to two to four percent into each MP that is being used for respiration testing. Helium injection will be used as a system leak-testing method, not as a general indicator of potential oxygen diffusion. Additional details on the *in situ* respiration test are found in Section 5.7 of the protocol document (Hinchee et al., 1992).

3.6 Air Permeability Tests

The objective of air permeability tests is to determine the areal extent of the subsurface soils (radius of influence) that can be oxygenated using one air injection VW. Air will be injected into the four-inch-diameter VW at the former heating oil UST sites using the portable blower unit. Pressure response will be measured at each MP with differential pressure gauges to determine the region influenced by the unit. Oxygen will also be monitored in the MPs to verify that oxygen levels in the soil increase as the result of air injection. One air permeability test, lasting four to eight hours, will be performed at each heating oil UST site. Because of the small (1 scfm) blower used at the Building 241 former gasoline UST site, an air permeability test will not be performed. However, the zone of oxygen influence will be determined by injecting air with the 1 scfm pump and monitoring O_2 and CO_2 concentrations in MPA.

3.7 Air Emissions Monitoring

Soil gas will not be extracted from the site during either the initial or extended pilot test. The proposed bioventing system for the two former heating oil UST sites will use a low rate (<30 scfm) of air injection to provide oxygen for enhanced biodegradation. Because these soils are contaminated with relatively small quantities of low-volatility heating oil, the potential for volatile emissions is very low. The proposed bioventing system for the former gasoline UST will use a flow rate of 1 scfm. This low flow rate and small quantity of soil contamination will reduce the potential for volatile emissions at this site as well. Because horizontal permeability is generally greater than vertical permeability, the injected air will tend to move outward rather than upward. This will promote *in situ* biodegradation of fuel vapor as it moves slowly outward from the center of the spill. Additionally, the test site is paved with asphalt, which will eliminate the potential for air emissions.

If some upward movement of injected air does occur, it will be highest during the first day of air injection when the initial soil gas volume is displaced. ES will carefully monitor the air in the breathing zone during the first day of testing. A PID will be

used to detect any emissions exceeding ambient conditions. The PID will be calibrated with benzene to detect BTEX compounds at the 1 ppmv level. This level of detection is consistent with the most conservative OSHA standards. Any sustained PID reading in excess of 1 ppmv will require an immediate reduction in air injection rates.

3.8 Installation of Extended (One-Year) Pilot Test Bioventing System

Extended (one-year) bioventing pilot test systems will be installed at the three former UST sites if the initial pilot tests successfully demonstrate the feasibility of providing oxygen throughout the contaminated soil profile. Continued air injection would determine the long-term radius of oxygen influence, and the effects of time, available nutrients, and changing temperatures on fuel biodegradation rates. A fixed blower unit will be installed at the two former heating oil UST sites as part of extended pilot test systems, and will be housed in a small, prefabricated shed to provide protection from the weather and to minimize noise. A small, portable 1 scfm blower will be installed in Building 241 at the former gasoline UST site. A Tygon hose running through a nearby window will connect the 1 scfm blower to the VW. Systems will be operated for one year.

Every six months, ES personnel will conduct *in situ* respiration tests to monitor the long-term performance of the bioventing systems. In addition, subsurface soil samples will be collected after one year at locations as close as possible to the original MP/VW soil sample locations in order to assess the degree of remediation achieved during the first year of *in situ* treatment. Weekly system checks will be performed by Los Angeles AFB personnel. If required, major maintenance of the blower unit will be performed by ES Pasadena or San Diego personnel. Detailed blower system information and a maintenance schedule will be included in the operation and maintenance (O&M) manual provided to the base. More detailed information regarding the test procedures are included in the protocol document (Hinchee et al., 1992).

4.0 EXCEPTIONS TO PROTOCOL PROCEDURES

Procedures used to construct MPs and VWs, and to measure soil permeability to air and *in situ* respiration rates, are described in Sections 4 and 5, respectively, of the protocol document (Hinchee et al., 1992). The only anticipated exception to the protocol is the 2-inch-diameter (instead of 4-inch-diameter) VW and the use of only one MP at the Building 241 former gasoline UST site.

5.0 BASE SUPPORT REQUIREMENTS

The following base support is needed prior to arrival of the drilling subcontractor and the ES pilot test team:

- Coordinating this work plan with local regulatory agencies and advising if any additional permits or information are required.
- Obtaining a base excavation permit.
- Confirmation of an available power source, and the installation of a 230-volt, 30-amp, single-phase breaker box with one 230-volt receptacle and two 110-volt receptacles located within 50 feet of the VWs at each site.

- Provision of any paperwork required to obtain gate passes and security badges for approximately three ES employees, two drillers, and an electrician (if a base electrician is not available). Vehicle passes will be needed for one truck and trailer, and a drill rig.
- Provision of keys to the on-site groundwater monitoring wells.

During initial testing, the following base support is needed:

- Twelve square feet of desk space and a telephone in a building located as close to the site as practical.
- The use of a facsimile machine for transmitting 15 to 20 pages of test results.
- A decontamination pad where the driller can clean augers between borings.
- Acceptance of responsibility for drill cuttings and decontamination water from VW and MP borings, including any drum sampling to determine hazardous waste status. (If ES transfers custody of drums to another contractor working on the base, assistance in arranging this transfer will also be needed).

During the one-year extended pilot tests, base personnel will be required to perform the following activities:

- Check the blower system once per week to ensure that it is operating and to record the air injection pressure and temperature. ES will provide a brief training session for this procedure and a maintenance procedures manual with data collection sheets.
- If the blower stops working, notify: Mr. Larry Dudus of ES San Diego at (619) 453-9650, Mr. Chris Pluhar of ES Pasadena at (818) 585-6324, or Mr. Jerry Hansen of AFCEE at (512) 536-4331.
- Arrange site access for an ES technician to conduct *in situ* respiration tests approximately six months and one year after the initial pilot test.

6.0 PROJECT SCHEDULE

The following schedule is contingent upon approval of this pilot test work plan and completion of base support requirements.

<u>Event</u>	<u>Date</u>
Pilot Test Work Plan to AFCEE/Los Angeles AFB	June 14, 1993
Approval to Proceed	June 18, 1993
Begin Initial Pilot Test	June 21, 1993
Interim Results Report	August 20, 1993
Respiration Test	December 1993
Final Respiration Test and Soil Sampling	June 1994

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- Engineering-Science, Inc., 1992. *Field Sampling Plan for AFCEE Bioventing*, Denver, Colorado.
- Hinchee, R.E., Ong, S.K., Miller, R.N., Downey, D.C., Frandt, R., 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing*, January.
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PART II

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PART II

DRAFT

BIOVENTING PILOT TEST INTERIM RESULTS REPORT BUILDING 241, GATE 3 AND, BUILDING 125 FORMER HEATING OIL UST SITES

1.0 INTRODUCTION

The purpose of this Part II report is to describe the results of the initial pilot tests at the Building 241, Building 125, and Gate 3 former heating oil UST sites, and to make specific recommendations for extended testing to determine the long-term impact of bioventing on-site contaminants. Initial bioventing pilot tests were completed at the Building 241, Gate 3 and, Building 125 former heating oil UST sites during 1 July through 19 July, and 17 and 18 November 1993. Routing electrical power to these sites for installation of the long-term pilot test blowers caused delays in pilot test completion. Description of the history, geology and contamination at all but the Building 125 former UST site are contained in Part I, the Bioventing Pilot Test Work Plan.

Part I contains the description of three sites where pilot tests were to be conducted. These three sites were the Building 241 former gasoline UST site (designated LA1), the Building 241 former heating oil UST site, and the Building 110 former heating oil UST site. Site conditions observed during the July 1993 field work eliminated two of these sites, Building 241 former gasoline UST site and Building 110 former heating oil UST site, from further consideration.

The vent well (LA1-VW) and one monitoring point (LA1-MPA) were installed at the Building 241 former gasoline UST site during a July 1992 investigation as described in Part I Subsection 3.1.3. Initial soil gas readings from LA1-VW and LA1-MPA during July 1993 field work detected O₂ concentrations of 5% or greater. This was considered sufficient oxygen for natural bioremediation to occur. No further pilot testing was conducted at this site. However, because of the proximity to the former heating oil UST site, LA1-VW and LA1-MPA were monitored during the Building 241 former heating oil UST site pilot test.

An initial soil gas survey was attempted at the Building 110 former UST site. Because of the high clay content of native soil and tank bed backfill material, soil gas samples could not be collected. One boring was attempted through the center of the former tank bed. In this boring, groundwater was encountered at 8 feet below ground

surface (bgs). Within a few minutes, the water level rose to approximately 5 feet bgs. Soil and groundwater from this boring had a strong petroleum odor. Because of the high groundwater at this site, no further pilot testing was conducted.

Pilot tests were conducted at the Gate 3 former heating oil UST site, and at the Building 125 former heating oil UST site to replace the two eliminated sites. The Gate 3 former heating oil UST site was described as an alternate site in the pilot test work plan. The Building 125 former heating oil UST site was included, during field work, as the third pilot test site. The description of site history, geology, and contamination for the Building 125 site is described in Section 4.0.

2.0 BUILDING 241 FORMER HEATING OIL UST SITE

2.1 Pilot Test Design and Construction

A soil gas survey was attempted prior to any site drilling. The high clay and moisture content of tank bed backfill material made sample collection impossible. Installation of an air injection vent well (VW) and three vapor monitoring points (MPs) at the Building 241 former heating oil UST site (designated LA2) began on 1 July 1993, and was completed on 5 July 1993. Drilling services were provided by Tonto Environmental Drilling of Fontana, California. Well installation and soil sampling were directed by Engineering-Science, Inc. (ES), geologists Mr. Larry Dudus and Mr. Chris Pluhar. The following sections describe the design and installation of the bioventing pilot test system at this site.

One VW (LA2-VW), three MPs (LA2-MPA, LA2-MPB, and LA2-MPC), and a blower unit were installed at the site. Figures 2.1 and 2.2, respectively, depict the location of, and a hydrogeologic cross section for, the VW and MPs completed at the site. A background MP was installed approximately 300 feet west of the site.

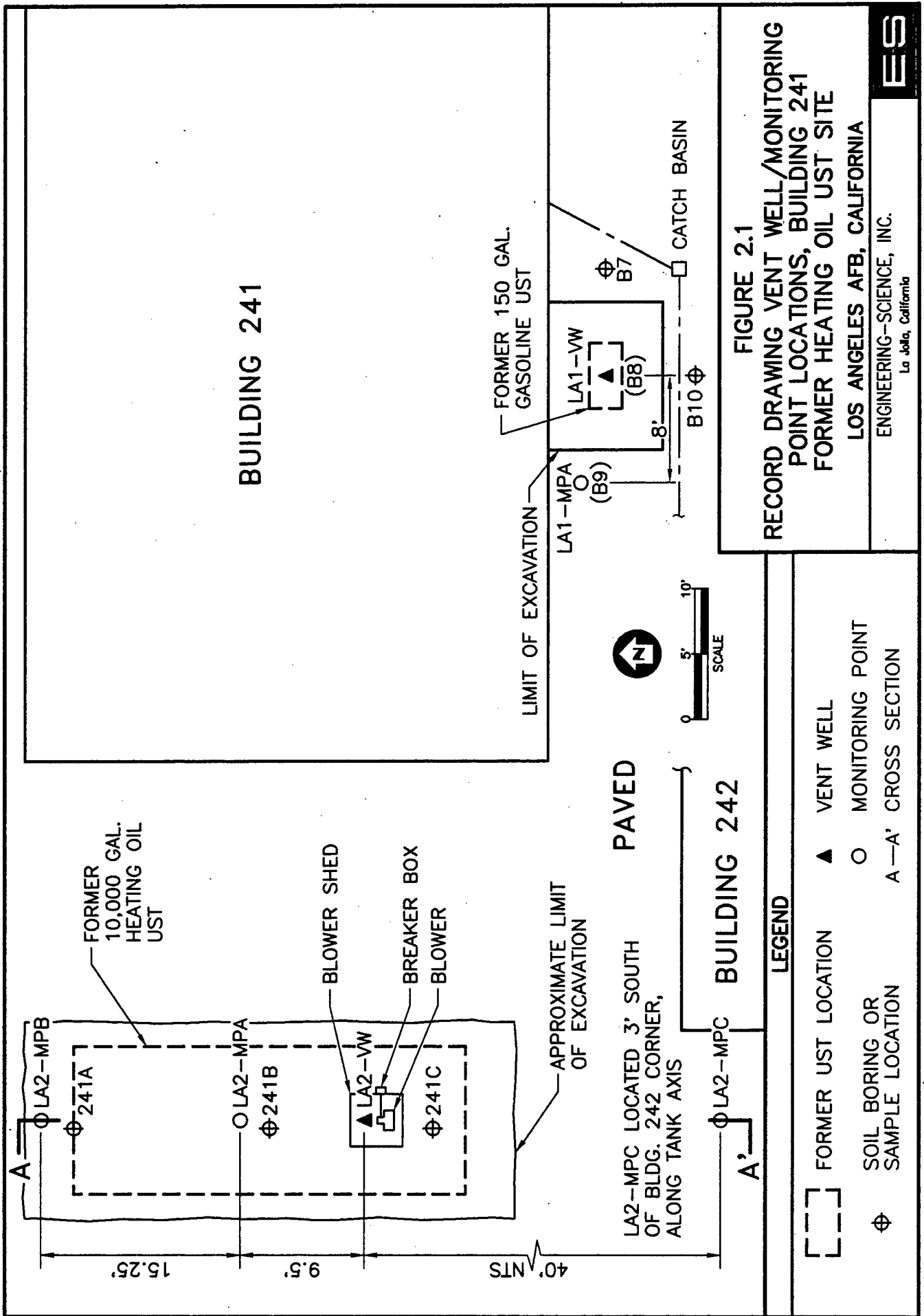
2.1.1 Air Injection Vent Well

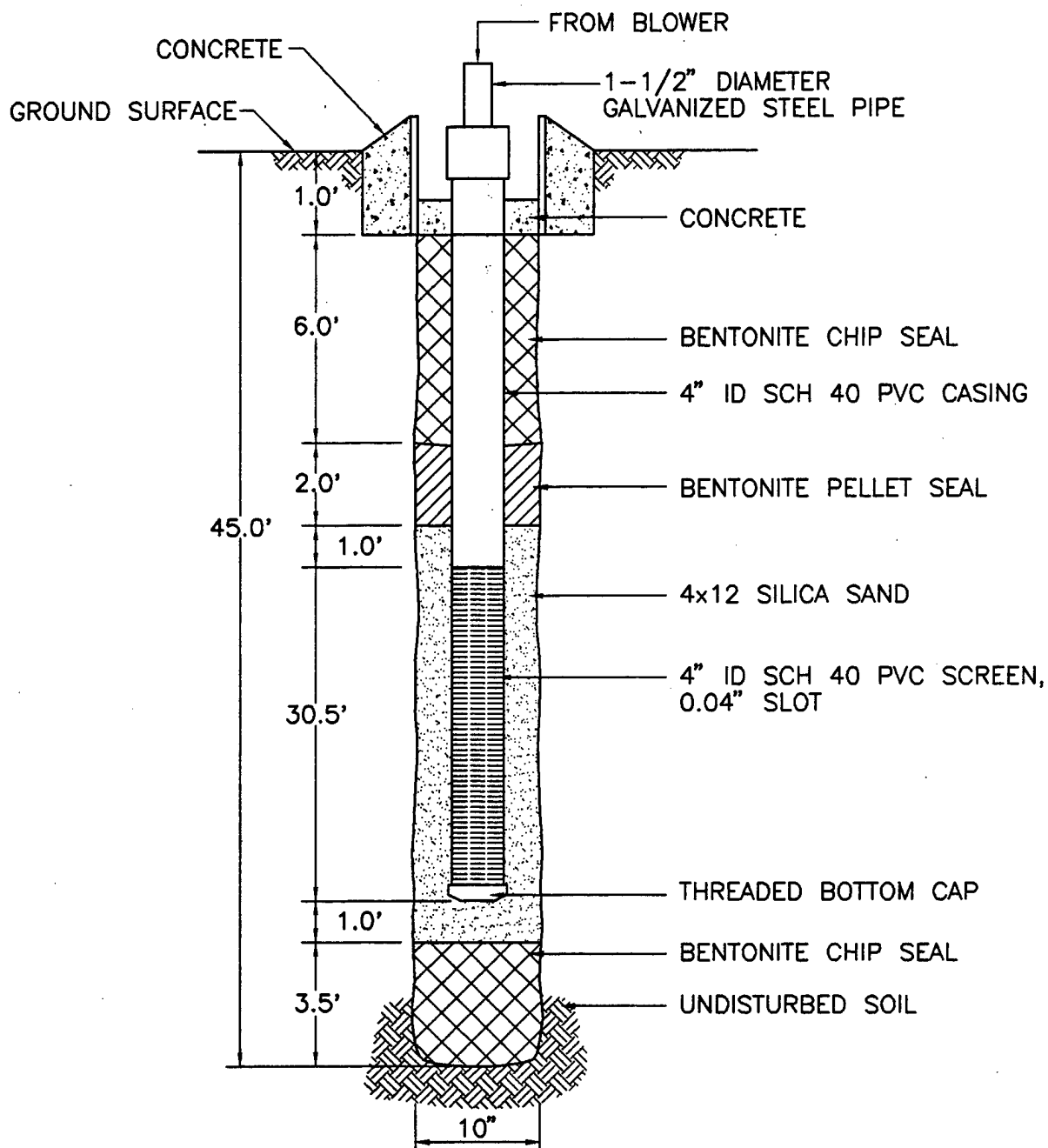
The air injection VW was installed following procedures described in the Air Force Center for Environmental Excellence (AFCEE) bioventing protocol document (Hinchee et al., 1992). Figure 2.3 shows construction details for LA2-VW.

The VW was installed through the former tank bed in hydrocarbon-contaminated soil. The VW was constructed using 4 inch diameter, Schedule 40 polyvinyl chloride (PVC) casing, with 30 feet of 0.04 inch slotted PVC screen installed from 10 to 40 feet bgs. The annular space between the well casing and borehole was filled with 4 x 12 silica sand from 41 feet bgs to approximately 1 foot above the well screen. Approximately 2 feet of bentonite pellets were placed above the sand and hydrated in place. Approximately 6 feet of bentonite chips were placed on top of the pellets and hydrated in place. The top of the well was completed with a flush mounted metal well vault set in a 2.5 x 2.5 x .5 foot concrete pad. The PVC well casing is connected to a galvanized steel riser pipe which is connected to the blower with a galvanized steel union.

2.1.2 Monitoring Points

The MP screens were installed at 10, 20, 30, and 40 foot depths. The three MPs were constructed as shown in Figures 2.2 and 2.4. Each MP monitoring interval was constructed using a 6 inch section of 1 inch diameter 0.02 inch slotted PVC well screen





NOT TO SCALE

FIGURE 2.3
RECORD DRAWING
AIR INJECTION VENT WELL
CONSTRUCTION DETAILS
BUILDING 241 FORMER
HEATING OIL UST SITE

LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
 La Jolla, California

ES

and a 0.25 inch diameter Schedule 80 PVC riser pipe extending to the ground surface. At the top of each riser, a ball valve and a 3/16 inch hose barb were installed. The top of each MP was completed with a flush-mounted metal well vault set in a concrete base. Thermocouples were installed at the 10 and 40 foot depths at LA2-MPA to measure soil temperature variations.

2.1.3 Blower Unit

A 1 horsepower Gast® regenerative blower unit was used for both the initial and the extended pilot tests. For the extended pilot test, the blower was installed in a small shed located directly over LA2-VW. The fixed unit is energized by 120 volt, single-phase, 20 amp power line from a breaker box in Building 241. The configuration, instrumentation, and specification for this blower system are shown on Figure 2.5. The blower is currently injecting air at a flow rate of approximately 72 cubic feet per minute (cfm) for the extended pilot test. After blower installation and start-up, ES engineers provided an operation and maintenance (O&M) manual, including maintenance instructions, equipment specifications, and monitoring forms, to base personnel. A copy of the O&M manual is provided in Appendix A.

2.2 Soil and Soil Gas Sampling Results

2.2.1 Soil Sampling Results

Soils at the site consist of silt and silty clay to approximately 15 feet bgs. In the former tank bed, backfill material was wet below a depth of approximately 5 feet bgs. The material had a strong petroleum odor and was visibly stained with petroleum. Below the native silt and silty clay, and the tank bed backfill material, a medium sand was encountered to a depth of approximately 38 feet bgs. Beneath the former tank bed (in LA2-VW, LA2-MPA, and LA2-MPB) the sand was heavily stained with petroleum and had a strong odor. However, no evidence of contamination was observed in LA2-MPC located approximately 40 feet south of the tank bed. In all borings, except LA2-MPA, clay was encountered from about 38 to 43 feet bgs. The clay appears to be sufficiently impermeable to prohibit any further downward migration of contamination. However, no clay was encountered in LA2-MPA and the sand which was encountered at 15 feet bgs continued, heavily stained, to at least 50 feet bgs at which depth the boring was terminated. More detailed hydrogeologic information regarding the site can be found in the hydrogeologic cross section (Figure 2.2) and the geological boring logs (Appendix B).

Soil samples for laboratory analysis were collected using 18 inch split-spoon samplers with 2 inch diameter brass liners. Soil samples were collected from LA2-VW at 10 and 15 feet bgs, LA2-MPA at 20 feet bgs, LA2-MPB at 40 feet bgs, and from LA2-MPC at 20 feet bgs. A sample was collected from each soil type including the backfill material. The sample from LA2-MPC was collected to confirm the absence of contamination and to help characterize the site.

Soil samples were shipped via Federal Express® to Pace laboratory in Novato, California, for chemical and physical analysis. Soil samples were analyzed for total recoverable petroleum hydrocarbons (TRPH); total petroleum hydrocarbons as diesel (TPH-D); benzene, toluene, ethylbenzene and xylenes (BTEX); iron; alkalinity; Total

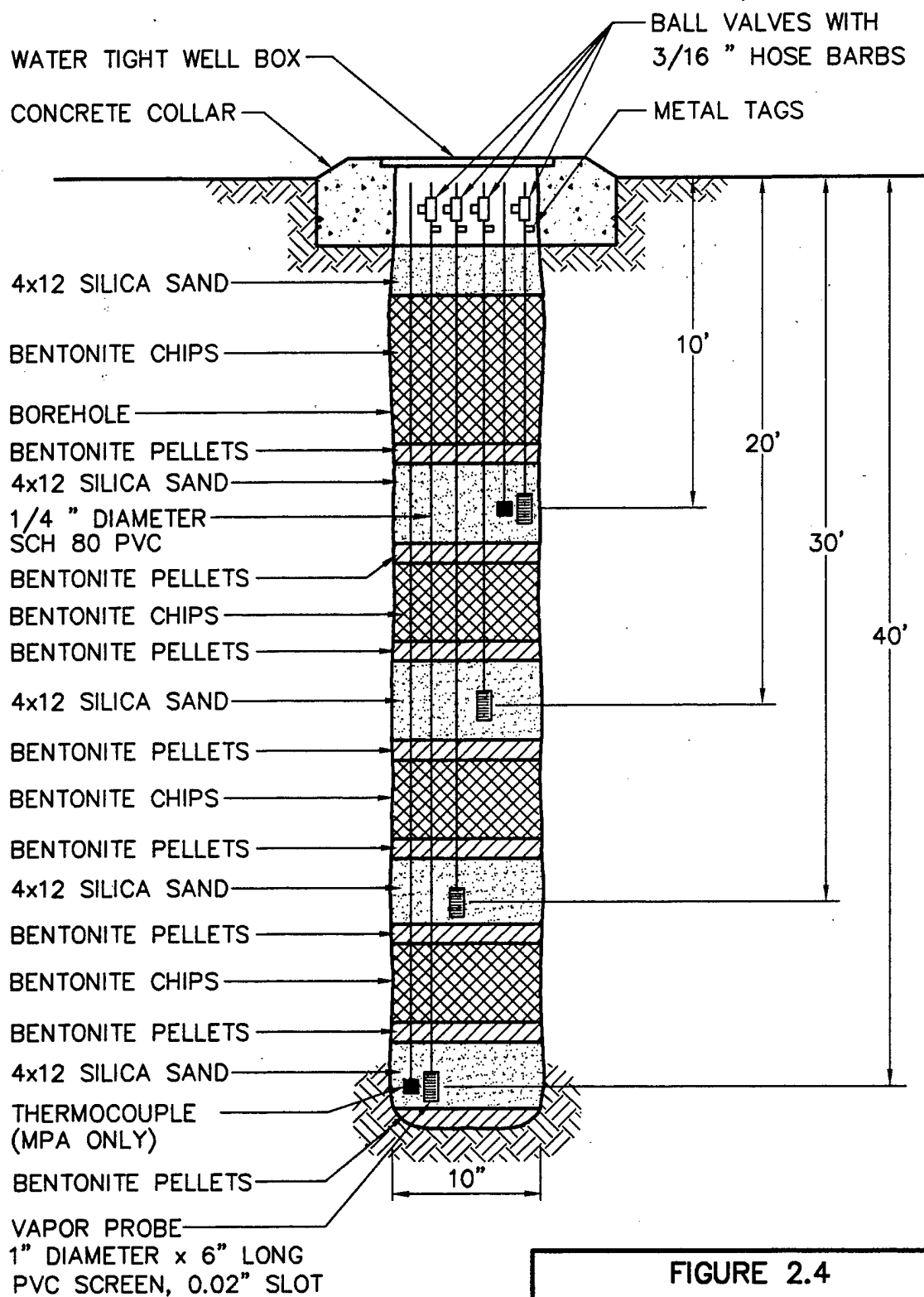


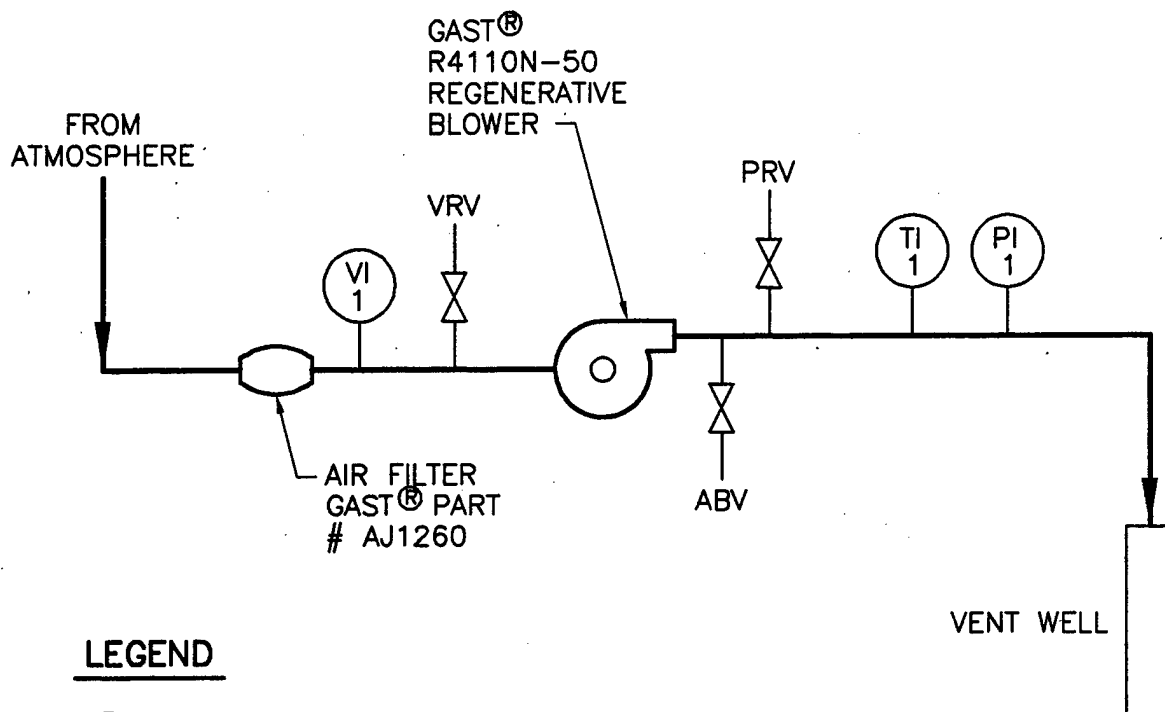
FIGURE 2.4
RECORD DRAWING
MONITORING POINT
CONSTRUCTION DETAILS
BUILDING 241 FORMER
HEATING OIL UST SITE

LOS ANGELES AFB, CALIFORNIA

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ES



LEGEND

PI 1 PRESSURE INDICATOR 0"-60" H₂O, GAST® PART # AJ496

TI 1 TEMPERATURE INDICATOR 0°-250°F, ASHCROFT®
PART # 30EI 6 OR 025 0/250F

VI 1 VACUUM INDICATOR -60"-0" H₂O, GAST® PART # AJ497

ABV AIR BLEED VALVE 1-1/2" GATE VALVE

PRV PRESSURE RELIEF VALVE 30"-170" H₂O, GAST® PART # AG258

VRV VACUUM RELIEF VALVE -170"-30" H₂O, GAST® PART # AG258

FIGURE 2.5
RECORD DRAWING BLOWER SYSTEM
INSTRUMENTATION DIAGRAM
FOR AIR INJECTION
BUILDING 241
FORMER HEATING OIL UST SITE
LOS ANGELES AFB, CALIFORNIA

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Kjeldahl Nitrogen (TKN); moisture content; and grain-size distribution. The results of these analyses are provided in Table 2.1. Chain-of-custody forms are provided in Appendix B.

2.2.2 Soil Gas Sampling Results

Soil gas samples were collected from LA2-VW and LA2-MPA at 20 feet bgs, and from LA2-MPB at 30 feet bgs. Soil gas samples were collected using 3-liter Tedlar® bags and a vacuum chamber. After the samples were collected in Tedlar® bags, they were transferred to 1-liter SUMMA® canisters and shipped to the laboratory.

Soil gas samples were shipped via Federal Express® to Air Toxics, Inc., in Rancho Cordova, California for total volatile hydrocarbons (TVH), BTEX, and methane analysis. The TVH analyses were referenced to jet fuel (Molecular Weight = 156) as there is no suitable analysis for the volatile fraction of heating oil or diesel. The results of these analyses are provided in Table 2.1. Chain-of-custody forms are provided in Appendix B.

2.3 Pilot Test Results

2.3.1 Exceptions to Test Protocol Procedures

Procedures described in the protocol document and the site-specific work plan (Part I) were used to complete the pilot test at this site. Exceptions to the Part I work plan included extending the total depths of the VW and MPs due to deeper than expected soil contamination. For this same reason, MPs were located further away from the VW than described in the Part I work plan. Because of high methane concentrations reported during other site investigations, methane analysis was added to the soil gas sample analytical parameters. Because of the similarity in composition of diesel and heating oil, soil samples were analyzed for TPH as diesel, as well as those analytes described in the protocol document.

2.3.2 Initial Soil Gas Chemistry

Prior to initiating air injection for the respiration test, the VW and all MPs were purged, and initial oxygen, carbon dioxide, and TVH concentrations were measured using portable gas analyzers, as described in the protocol document.

Table 2.2 summarizes the initial soil gas chemistry at the site. The results strongly indicate that biological fuel degradation has depleted the oxygen supply in the vadose zone. The VW and all MPs installed in contaminated soil, except MPB-10, contained oxygen levels of 0 to 1 percent. MPC, installed in apparently clean soil approximately 40 feet from the former UST bed also had reduced oxygen concentrations of between four and nine percent. Carbon dioxide was present at elevated concentrations, ranging from 3.0 and 13.1 percent. LA1-VW and LA1-MPA were also monitored because of the close proximity to the Building 241 former heating oil UST site.

A background MP (LA-BG) was installed approximately 300 feet west of the site. The background MP was installed in an area with no known sources of contamination. Though soil from the background MP exhibited no field evidence of contamination, initial soil gas readings had lower oxygen concentrations than observed in MPC located 30 feet away from a mass of contaminated soil approximately 30 feet in diameter and 40 feet deep. Soil gas samples collected from the background MP at 25 and 40 feet bgs

Table 2.1

**Soil and Soil Gas Laboratory Analytical Results
Building 241 Former Heating Oil UST Site
Los Angeles AFB, California**

Analyte (Units) ^a	Sample Location - Depth (Feet Below Ground Surface)				
Soil Gas Hydrocarbons	LA2-VW	LA2-MPA-20	LA2-MPB-30	LA-BG-25	LA-BG-40
TVH ^b (ppmv)	380	360	280	19	41
Benzene (ppmv)	0.091	0.096	ND (0.013)	ND (0.002)	ND (0.002)
Toluene (ppmv)	0.47	0.41	0.045	ND (0.002)	ND (0.002)
Ethylbenzene (ppmv)	0.99	0.64	0.14	ND (0.002)	0.003
Xylenes (ppmv)	1.3	1.2	0.23	0.018	0.025
Methane (%)	0.24	0.23	0.58	NA	NA
Soil Hydrocarbons	LA2-VW-10	LA2-VW-15	LA2-MPA-20	LA2-MPB-40	LA2-MPC-20
TPH-D ^c (mg/kg)	350 ^e	NA	13,500	1,080	ND (5)
TRPH ^d	91	NA	11,800	2,470	ND (12)
Benzene (mg/kg)	ND (0.0003)	NA	ND (0.038)	ND (0.002)	ND (0.003)
Toluene (mg/kg)	ND (0.0003)	NA	0.07	ND (0.002)	ND (0.003)
Ethylbenzene (mg/kg)	.0016	NA	1.4	0.006	ND (0.003)
Xylenes (mg/kg)	.0046	NA	1.4	0.031	ND (0.008)
Soil Inorganics					
Iron (mg/kg)	30,500	20,100	NA	50,700	NA
Alkalinity (mg/kg as Ca CO ₃ ^f)	1,060	880	NA	560	NA
pH (Units)	6.3	7.8	NA	8.5	NA
TKN ^g (mg/kg)	150	83	NA	130	NA
Phosphates (mg/kg)	1,700	1,100	NA	2,100	NA
Soil Physical Parameters					
Moisture (% wt)	18	18	5.4	29	15
Gravel (%)	4.2	0.0	NA	2.9	NA
Sand (%)	36.8	88.8	NA	26.1	NA
Silt (%)	34.3	9.5	NA	46.9	NA
Clay (%)	24.6	1.8	NA	24.0	NA

^a ppmv = Parts Per Million, Volume Per Volume; mg/kg = Milligrams Per Kilogram

^b TVH = Total Volatile Hydrocarbons referenced to Jet Fuel (MW=156).

^c TPH-D = Total Petroleum Hydrocarbons as Diesel by SW 8015 Modified.

^d TRPH = Total Recoverable Petroleum Hydrocarbons by EPA 418.1.

^e Surrogate recovery outside established control limits.

^f Ca CO₃ = Calcium Carbonate

^g TKN = Total Kjeldahl Nitrogen

NA = Not Analyzed

ND = None Detected. Method detection limits are in parentheses.

Table 2.2
Initial Soil Gas Chemistry
Building 241 Former Heating Oil UST Site
Los Angeles AFB, California

Sample Location	Depth (ft bgs)	O ₂ (percent)	CO ₂ (percent)	TVH-Field (ppmv) ^a	TVH-Lab (ppmv) ^b	Temperature °F
LA2-VW	10-40.5	1.0	12.5	1250	380	NA
LA2-MPA-10	10	0.0	3.0	660	NA	71.0
LA2-MPA-20	20	0.0	13.0	720	360	NA
LA2-MPA-30	30	0.0	13.1	1220	NA	NA
LA2-MPA-40	40	0.0	13.0	820	NA	73.2
LA2-MPB-10	10	8.2	6.8	200	NA	NA
LA2-MPB-20	20	0.0	12.4	610	NA	NA
LA2-MPB-30	30	0.0	12.0	600	280	NA
LA2-MPB-40	40	0.0	12.5	1400	NA	NA
LA2-MPC-10	10	9.0	6.2	190	NA	NA
LA2-MPC-20	20	8.0	8.5	175	NA	NA
LA2-MPC-30	30	9.0	8.5	180	NA	NA
LA2-MPC-40	40	4.0	11.0	200	NA	NA
LA1-VW	5-15.25	5.2	10.0	280	NA	NA
LA1-MPA-7.6	7.6	3.9	8.5	140	NA	NA
LA1-MPA-13.3	13.3	6.0	10.0	155	NA	NA
LA1-MPA-19	19	5.2	10.1	155	NA	NA
LA-BG-10	10	7.2	10.0	62	NA	NA
LA-BG-25	25	7.0	10.2	54	19	NA
LA-BG-40	40	2.5	9.0	480	41	NA

^a Total hydrocarbon analyzer field screening results.

^b Laboratory results referenced to Jet Fuel (MW = 156).

NA = Not Analyzed.

has TVH concentrations of 19 ppmv and 41 ppmv respectively. Traces of Xylenes and Ethylbenzene were also detected (Table 2.1). A possible explanation is that the background MP lies within a zone of depleted oxygen from an unidentified natural or refined hydrocarbon source. Because the background MP appears to be unrepresentative of true background conditions, respiration test data was not used for comparison with respiration data for the other three sites.

2.3.3 *In Situ* Respiration Rates

An *in situ* respiration test was conducted at the site according to protocol document procedures. Four 1 cfm pumps were used to inject air into MPA-10, MPA-20, MPA-30, and MPA-40 for 20 hours. Helium, at a concentration of between 3 and 4 percent was also injected into each point. Oxygen concentrations at each MPA point were increased to at least 19.1 percent. After air injection ceased, changes in soil gas composition were monitored over time. Oxygen, carbon dioxide, TVH, and Helium were measured over a period of between 35 to 78 hours following the air injection period. The observed rates of oxygen utilization were then used to estimate the aerobic fuel degradation rates at the site using procedures outlined in Section 5.7 of the protocol document. Figures 2.6 through 2.9 present the results of *in situ* respiration testing at the site, and Table 2.3 provides a summary of the observed oxygen utilization rates. The oxygen utilization rates observed in contaminated soils ranged from 0.00333 percent per minute (%/min) to 0.0126 %/min, indicating that the highest levels of biological activity are located at the shallower, more contaminated depths. Helium levels remained relatively constant when compared to oxygen utilization, indicating that diffusions or MP leaks were not contributing to oxygen loss.

An estimated 640 to 2,860 milligrams (mg) of fuel per kilogram (kg) of soil can be degraded each year. This value is the range of the fuel consumption rates calculated for the four probe depths at LA2-MPA. The point-specific fuel consumption rates were calculated using observed oxygen utilization rates, an estimated air-filled porosity ranging from 0.086 to 0.152 liters of air/kg of soil, and a conservative ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded.

2.3.4 Air Permeability

An air permeability test was conducted at the site according to protocol document procedures. Air was injected into the VW for approximately 18 hours at a rate of approximately 70 cubic feet per minute (cfm) and an average pressure of approximately 16 inches of water. The pressure responses at each MP are listed in Table 2.4. The pressure measured at most MPs continued to increase for approximately three hours after which pressures remained stable or dropped slightly. The dynamic method of determining air permeability is coded in the HyperVentilate® model that was used to calculate soil gas permeability values ranging from 59 darcys to 132 darcys for this site. A minimum radius of pressure influence of 40 feet was observed at all depths with an influence of at least 60 feet at the 5 to 20 foot interval.

2.3.5 Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the central VW during pilot testing is the primary design parameter for full-scale bioventing systems. Optimization of full-scale and multiple VW systems

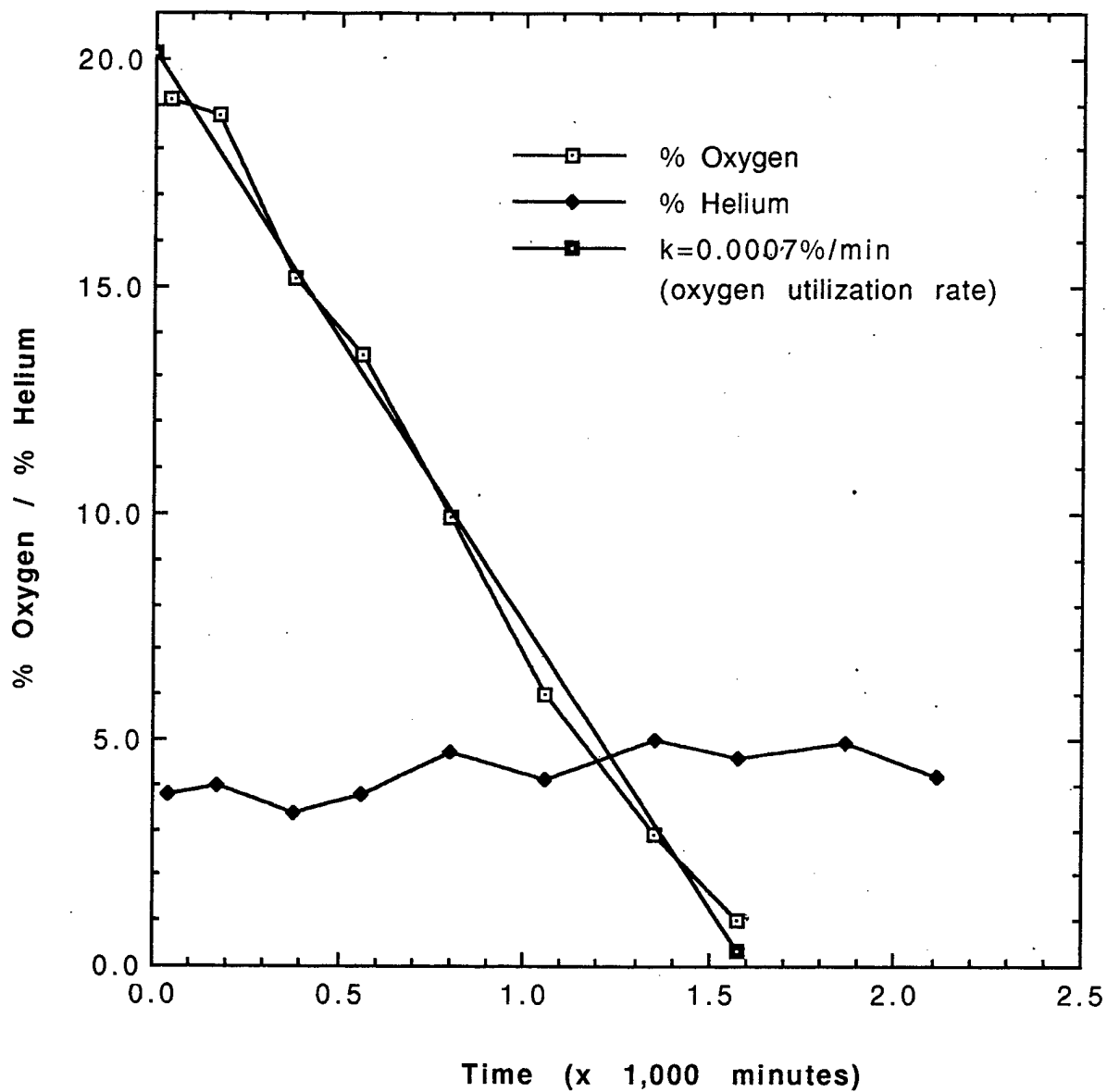


FIGURE 2.6
Respiration Test
LA2-MPA10'
Building 241
Former Heating Oil UST Site

Engineering-Science, Inc.

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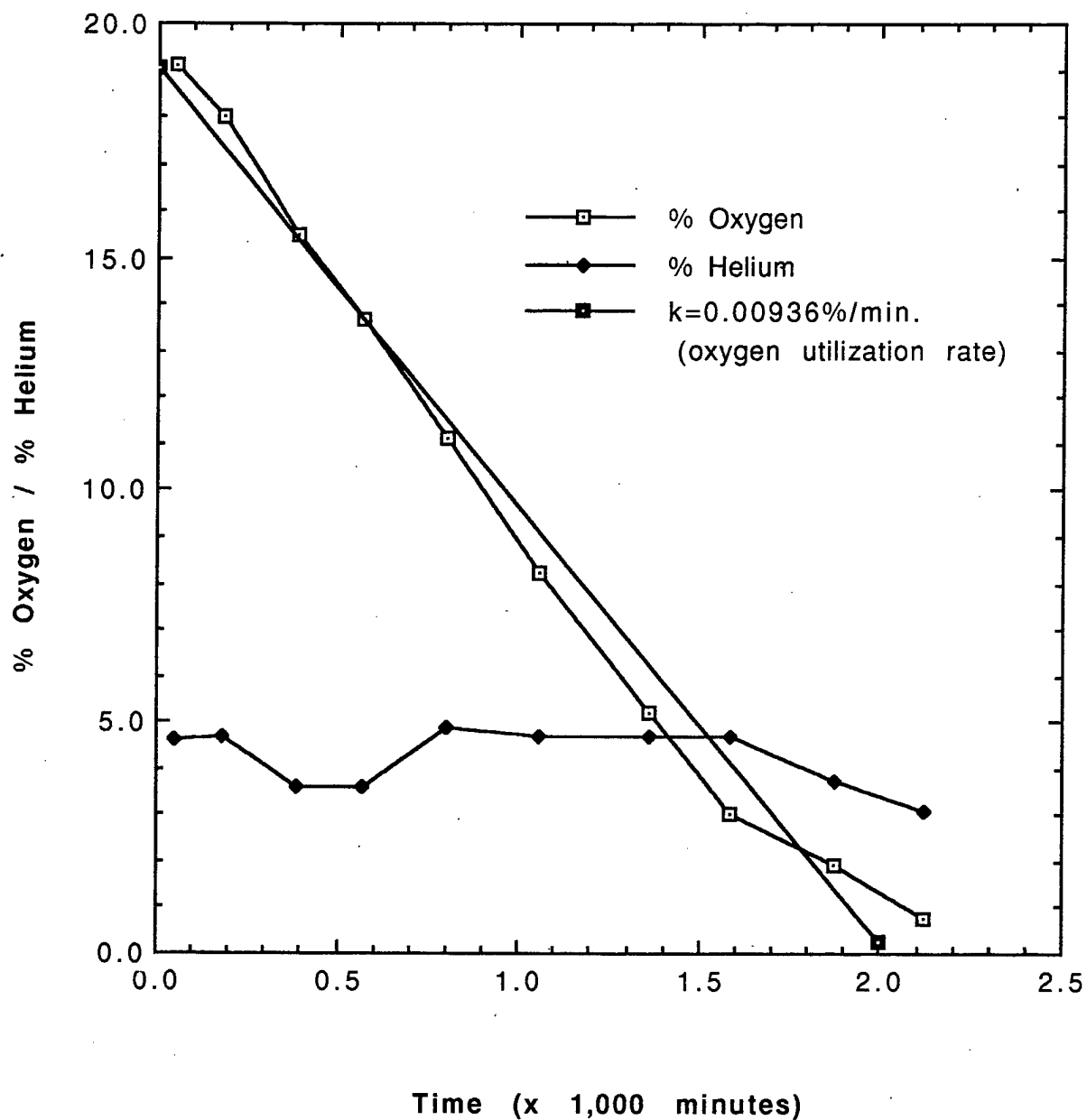


FIGURE 2.7
Respiration Test
LA2-MPA20'
Building 241
Former Heating Oil UST Site

Engineering-Science, Inc.

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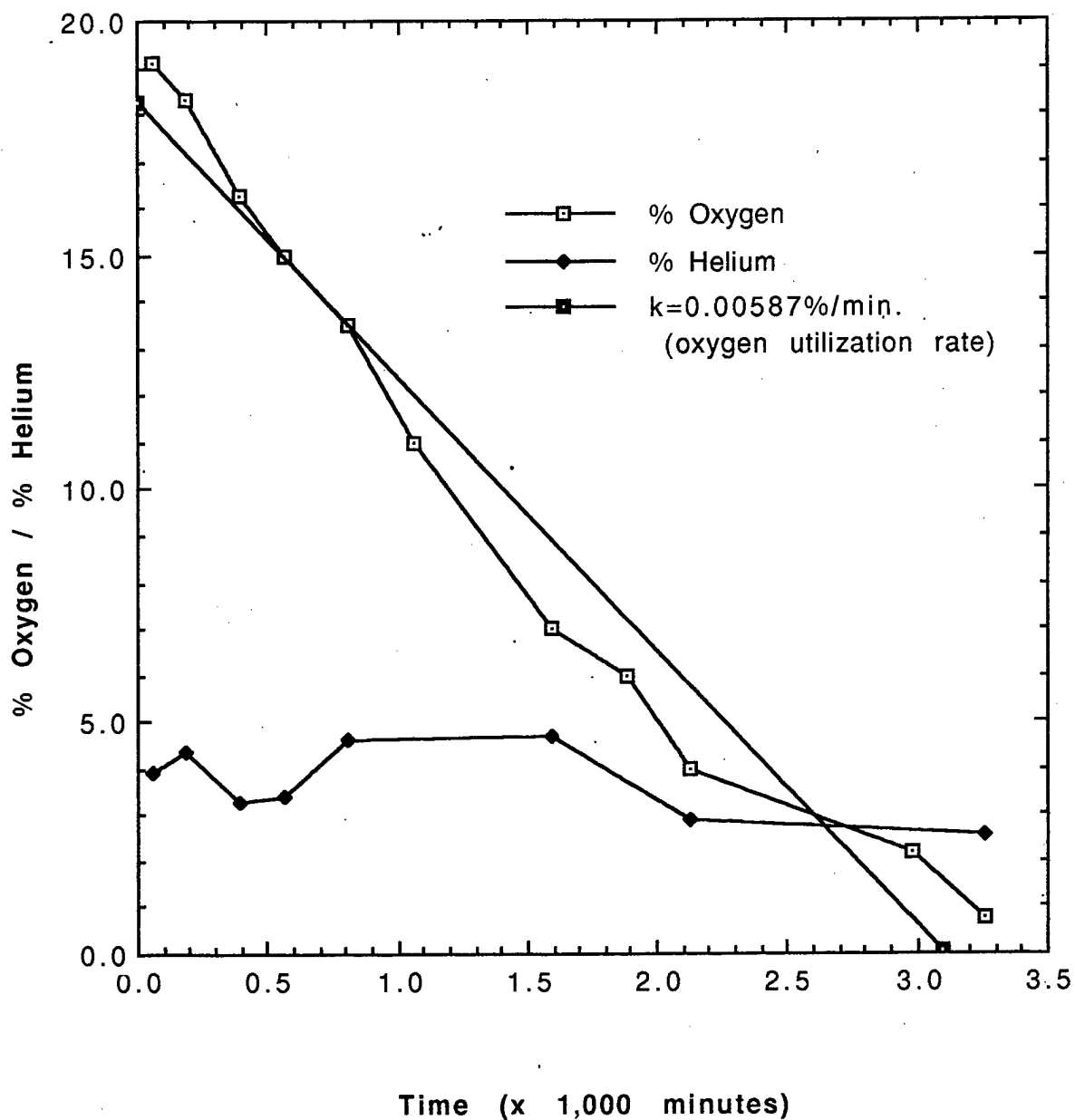


FIGURE 2.8
Respiration Test
LA2-MPA30'
Building 241
Former Heating Oil UST Site

Engineering-Science, Inc.

ES

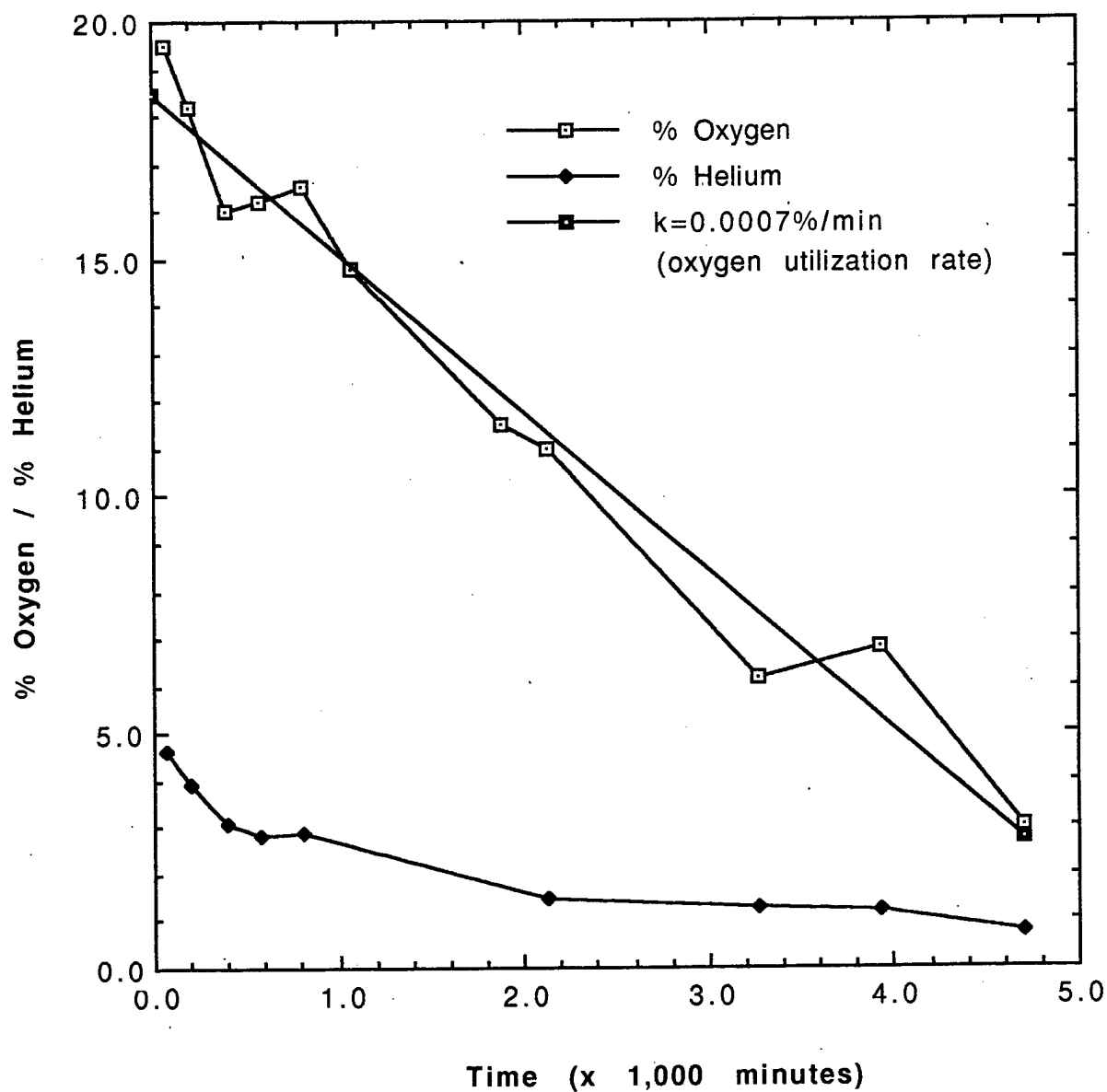


FIGURE 2.9
Respiration Test
LA2-MPA40'
Building 241
Former Heating Oil UST Site

Engineering-Science, Inc.

ES

Table 2.3
Oxygen Utilization Rates
Building 241 Former Heating Oil UST Site
Los Angeles AFB, California

MP	O ₂ Loss ^a (percent)	Test Duration (min.)	O ₂ Utilization ^a Rate (percent/min)	Hydrocarbon Degradation Rate (mg/kg/yr)
LA2-MPA-10	19.79	2100	0.0007	2180
LA2-MPA-20	18.13	2100	0.00936	2860
LA2-MPA-30	17.40	3300	0.00587	1800
LA2-MPA-40	15.69	4700	0.0007	640

^a Values based on linear regression (Figures 2.6 through 2.9).

Table 2.4

**Pressure Response (Inches of Water) During Air Permeability Test
Building 241 Former Heating Oil UST Site
Los Angeles AFB, California**

Location	MPA				MPB				MPC				LA1-VW	LA1-MPA ₁	
Depth (ft. bgs)	10	20	30	40	10	20	30	40	10	20	30	40	5-15.25	13	19
Elapsed Time (min)															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.5	3.0	3.0	0.4	0.4	0.8	0.9	1.2	0.10	0.10	0.10	0	0.05	0.1	0.1
2	1.0	3.4	3.4	0.6	0.7	1.0	1.15	1.5	0.30	0.35	0.35	0.05	0.10	0.2	0.25
3									0.45	0.5	0.55	0.15	0.25	0.3	0.35
4	1.2	3.9	3.8	0.7	0.9	1.25	1.45	2.0	0.55	0.55	0.65	0.25	0.3	0.35	0.35
5	1.5	4.0	3.9	0.7	0.95	1.35	1.5	2.2	0.65	0.65	0.70	0.25	0.35	0.45	0.45
6	1.5	4.0	4.0	0.8	1.05	1.45	1.53	2.3	0.70	0.70	0.80	0.30	0.35	0.45	0.50
7	1.5	4.1	4.0	0.8	1.10	1.5	1.6	2.4	0.70	0.75	0.85	0.35	0.40	0.55	0.55
8	1.5	4.1	4.0	0.8	1.1	1.5	1.6	2.5	0.75	0.80	0.85	0.35	0.45	0.55	0.60
9	1.5	4.2	4.1	0.9	1.2	1.53	1.7	2.6	0.80	0.80	0.85	0.40	0.50	0.60	0.60
10	1.5	4.2	4.2	0.9	1.2	1.55	1.75	2.65	0.85	0.85	0.90	0.40	0.50	0.60	0.60
12	1.7	4.3	4.2	0.95	1.3	1.6	1.8	2.7	0.85	0.90	0.95	0.45	0.50	0.70	0.70
14	1.7	4.3	4.2	0.95	1.25	1.65	1.8	2.8	0.90	0.90	1.0	0.50	0.55	0.70	0.70
16	1.7	4.4	4.3	1.0	1.3	1.65	1.85	2.85	0.95	0.95	1.0	0.55	0.55	0.70	0.75
18	1.8	4.4	4.3	1.0	1.4	1.7	1.85	2.9	0.95	1.0	1.05	0.55	0.60	0.75	0.75
20	1.8	4.4	4.3	1.0	1.4	1.75	1.9	2.95	0.95	1.0	1.05	0.60	0.60	0.75	0.75
22	1.8	4.4	4.4	1.05	1.4	1.75	1.9	2.95	0.95	1.0	1.05	0.65	0.60	0.80	0.80
24	1.8	4.4	4.4	1.1	1.4	1.75	1.9	3.0	0.95	0.95	1.05	0.65	0.60	0.80	0.80
28	1.8	4.4	4.4	1.1	1.4	1.75	1.9	3.0	0.95	1.0	1.05	0.65	0.60	0.80	0.80
30	1.8	4.4	4.4	1.1	1.4	1.75	1.9	3.0	1.0	1.0	1.10	0.70	0.60	0.80	0.80
33	1.8	4.4	4.4	1.1	1.4	1.75	1.9	3.0	1.0	1.0	1.05	0.70	0.60	0.80	0.80
36	1.8	4.45	4.4	1.2	1.4	1.75	1.9	3.0	.95	1.0	1.05	0.65	0.60	0.75	0.75
39	1.8	4.45	4.4	1.2	1.4	1.75	1.9	3.0	1.0	.95	1.05	0.70	0.60	0.80	0.80
42	1.8	4.45	4.4	1.2	1.4	1.75	1.95	3.0	1.0	1.0	1.05	0.70	0.60	0.80	0.80
45	1.9	4.45	4.4	1.2	1.4	1.75	1.95	3.05	1.0	1.0	1.08	0.75	0.60	0.80	0.82
48	1.9	4.5	4.45	1.2	1.4	1.75	1.95	3.05	1.00	1.02	1.10	0.72	0.62	0.80	0.80
51	1.9	4.5	4.45	1.2	1.4	1.75	1.9	3.05	1.0	1.0	1.05	0.78	0.60	0.78	0.78
54	1.9	4.5	4.45	1.2	1.4	1.75	1.95	3.05	1.02	1.02	1.10	0.80	0.64	0.78	0.82
57	1.9	4.3	4.45	1.2	1.4	1.75	1.95	3.05	1.02	1.0	1.10	0.82	0.64	0.80	0.80

Table 2.4 (Cont.)
Pressure Response (Inches of Water) During Air Permeability Test
Building 241 Former Heating Oil UST Site
Los Angeles AFB, California

<u>Location</u>	<u>MPA</u>				<u>MPB</u>				<u>MPC</u>				<u>LA1-VW</u>	<u>LA1-MPA₁</u>	
<u>Depth</u> (ft. bgs)	10	20	30	40	10	20	30	40	10	20	30	40	5-15.25	13	19
Elapsed Time (min)															
60	1.9	4.5	4.45	1.2	1.4	1.75	1.95	3.05	1.04	1.02	1.12	0.85	0.65	0.80	0.80
75	1.9	4.5	4.45	1.3	1.4	1.75	1.95	3.05	1.02	1.04	1.15	0.88	0.65	0.80	0.80
90	1.9	4.5	4.45	1.4	1.4	1.80	1.95	3.10	1.02	1.02	1.15	0.95	0.60	0.80	0.80
105	1.9	4.5	4.55	1.4	1.4	1.78	1.95	3.15	1.00	1.00	1.10	0.90	0.60	0.80	0.80
120	1.9	4.5	4.5	1.4	1.4	1.78	1.95	3.15	1.05	1.05	1.15	0.98	0.60	0.80	0.82
150	1.9	4.6	4.6	1.5	1.4	1.78	1.95	3.18	1.08	1.05	1.12	1.00	0.64	0.80	0.85
180	2.0	4.6	4.6	1.7	1.4	1.8	1.95	3.2	1.10	1.10	1.18	1.05	0.62	0.80	0.82
240	1.9	4.5	4.6	1.4	1.4	1.75	1.92	3.15	1.05	1.05	1.15	0.98	0.60	0.75	0.78
340	1.75	4.5	4.5	1.2	1.4	1.72	1.9	3.05	1.0	1.0	1.1	0.75	0.55	0.70	0.75
1120	1.9	4.55	4.55	1.0	1.4	1.75	1.9	3.1	1.0	1.0	1.1	0.50	0.55	0.75	0.75

1 LA1-MPA-7 not measured.

requires pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 2.5 describes the change in soil gas oxygen levels that occurred after 18 hours of air injection during the air permeability test at the site. This air injection period at 70 cfm produced changes in soil gas oxygen levels at a distance of at least 40 feet from the central VW at all depths in MPC. Based on measured pressure response in LA1-VW, which is an indicator of long-term oxygen transport, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 60 feet at all depths. Monitoring during the extended pilot test at this site will better define the long-term effective treatment radius.

2.3.6 Potential Air Emissions

Site contamination consists of heating oil, a compound of relatively low volatility. Soil samples, heavily stained with the oil, had maximum field head space readings of 150 ppm. The maximum concentration of TVH and benzene compounds detected in soil gas samples was 380 ppmv and 0.096 ppmv, respectively. The long-term potential for air emissions from full-scale bioventing operations at this site is low. Initial emissions should be minimal because accumulated vapors will move slowly outward from the air injection point and will be biodegraded as they move horizontally through the soil. During the air permeability test, air was injected at 70 cfm. Health and safety hydrocarbon-analyzer air monitoring of the breathing zone at the site indicated that total hydrocarbon concentrations did not increase above 1 ppmv during the initial days of the test. The initial day of bioventing generally produces the highest potential for emissions as the first pore volume of soil gas is replaced.

2.4 Recommendations

Initial bioventing tests at this site indicate that oxygen had been depleted in the contaminated soils, and that air injection is an effective method of stimulating aerobic fuel biodegradation. AFCEE has recommended that air injection continue at this site to determine the long-term radius of oxygen influence and the effects of time, available nutrients, and changing temperatures on fuel biodegradation rates.

A 1 horsepower regenerative blower has been installed at the site for continuous air injection. In May 1994, ES will return to the site to sample and analyze the soil gas and conduct a repeat respiration test. In December 1994, a final respiration test will be conducted, and soil and soil gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

3.0 GATE 3 FORMER HEATING OIL UST SITE

3.1 Pilot Test Design and Construction

A soil gas survey was attempted prior to any site drilling. The high clay and moisture content of the tank bed backfill material made sample collection impossible. Installation of an air injection vent well (VW) and three vapor monitoring points (MPs) at the Gate 3 former heating oil UST site (designated LA3) began on 6 July 1993, and was completed on 7 July 1993. Drilling services were provided by Tonto Environmental Drilling, of Fontana, California. Well installation and soil sampling

Table 2.5

**Building 241 Former Heating Oil UST Site
Influence of Air Injection Vent Well on Monitoring Point Oxygen Levels
Los Angeles AFB, California**

Sample Location	Distance from VW (ft)	Depth (ft. bgs)	Initial O ₂ (percent)	Final O ₂ ^a (percent)
LA2-MPA-10	9.5	10	0.0	3.0
LA2-MPA-20	9.5	20	0.0	18.8
LA2-MPA-30	9.5	30	0.0	20.0
LA2-MPA-40	9.5	40	0.0	19.0
LA2-MPB-10	24.75	10	9.2	1.5
LA2-MPB-20	24.75	20	0.0	17.0
LA2-MPB-30	24.75	30	0.0	18.0
LA2-MPB-40	24.75	40	0.0	17.0
LA2-MPC-10	40	10	8.2	15.0
LA2-MPC-20	40	20	8.0	18.2
LA2-MPC-30	40	30	7.8	18.5
LA2-MPC-40	40	40	4.0	12.0
LA1-VW	62	5-15.25	12.4	6.0
LA1-MPA-7	53	7	NS	NS
LA1-MPA-13	53	13	7.0	5.2
LA1-MPA-19	53	19	6.4	3.0

^a Readings taken after 18 hours of air injection during air permeability test.

NS = Not Sampled.

were directed by ES geologists Mr. Larry Dudus and Mr. Chris Pluhar. The following sections describe the final design and installation of the bioventing pilot test system at this site.

One VW (LA3-VW), three MPs (LA3-MPA, LA3-MPB, and LA3-MPC), and a blower unit were installed at the site. Figures 3.1 and 3.2, respectively, depict the location of, and a hydrogeologic cross section for, the VW and MPs completed at the site.

3.1.1 Air Injection Vent Well

The air injection VW was installed following procedures described in the AFCEE bioventing protocol document. Figure 3.3 shows construction details for LA3-VW.

The VW was installed through the former tank bed in hydrocarbon-contaminated soil. The VW was constructed using 4 inch diameter, Schedule 40 PVC casing, with 40 feet of 0.04 inch slotted PVC screen installed from 14.5 to 54.5 feet bgs. The annular space between the well casing and borehole was filled with 4 x 12 silica sand from 55 feet bgs to approximately 1.5 foot above the well screen. Approximately 2 feet of bentonite pellets were placed above the sand and hydrated in place. Approximately 10 feet of bentonite chips were placed on top of the pellets and hydrated in place. The top of the well was completed with a flush mounted metal well vault set in a 2.5 x 2.5 x .5 foot concrete pad.

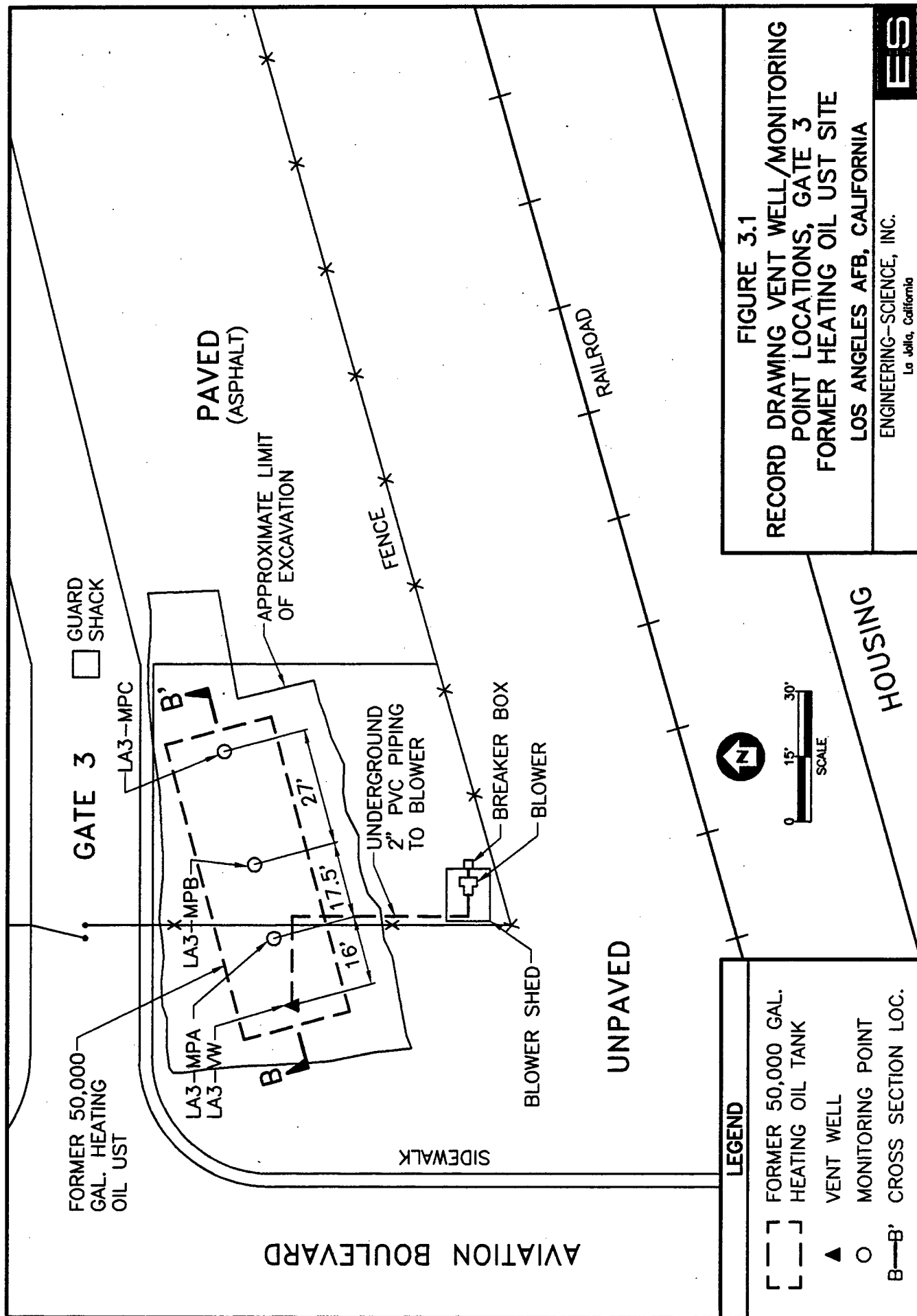
The well casing was finished with a tee fitting, approximately 6 inches bgs. The fitting is attached to a 2 inch diameter, Schedule 40 PVC pipe which runs underground for approximately 65 feet to the blower. The PVC pipe is connected to a galvanized steel riser pipe, which is connected to the blower with a galvanized steel union.

3.1.2 Monitoring Points

The MP screens were installed at 20, 30, 40 and 55 foot depths. The three MPs (LA3-MPA, LA3-MPB, and LA3-MPC) were constructed as shown in Figures 3.2 and 3.4. Each MP monitoring interval was constructed using a 6 inch section of 1 inch diameter 0.02 inch slotted PVC well screen and a 0.25 inch diameter Schedule 80 PVC riser pipe extending to the ground surface. At the top of each riser, a ball valve and a 3/16 inch hose barb were installed. The top of each MP was completed with a flush-mounted metal well vault set in a concrete base. Thermocouples were installed at the 10 and 55 foot depths at LA3-MPA to measure soil temperature.

3.1.3 Blower Unit

A 1 horsepower Gast® regenerative blower unit was used for both the initial and the extended pilot tests. For the extended pilot test, the blower was installed in a small shed located approximately 55 feet southeast of LA3-VW, inside the base perimeter security fence. The fixed unit is energized by 120 volt, single-phase, 20-amp power line from an Edison power pole located on Aviation Boulevard. The configuration, instrumentation, and specifications for this blower system are shown on Figure 3.5. The blower is currently injecting air at a flow rate of approximately 35 cfm for the extended pilot test. After blower installation and start-up, ES engineers provided an O&M manual, including maintenance instructions, equipment specifications, and monitoring forms, to base personnel. A copy of the O&M manual is provided in Appendix A.



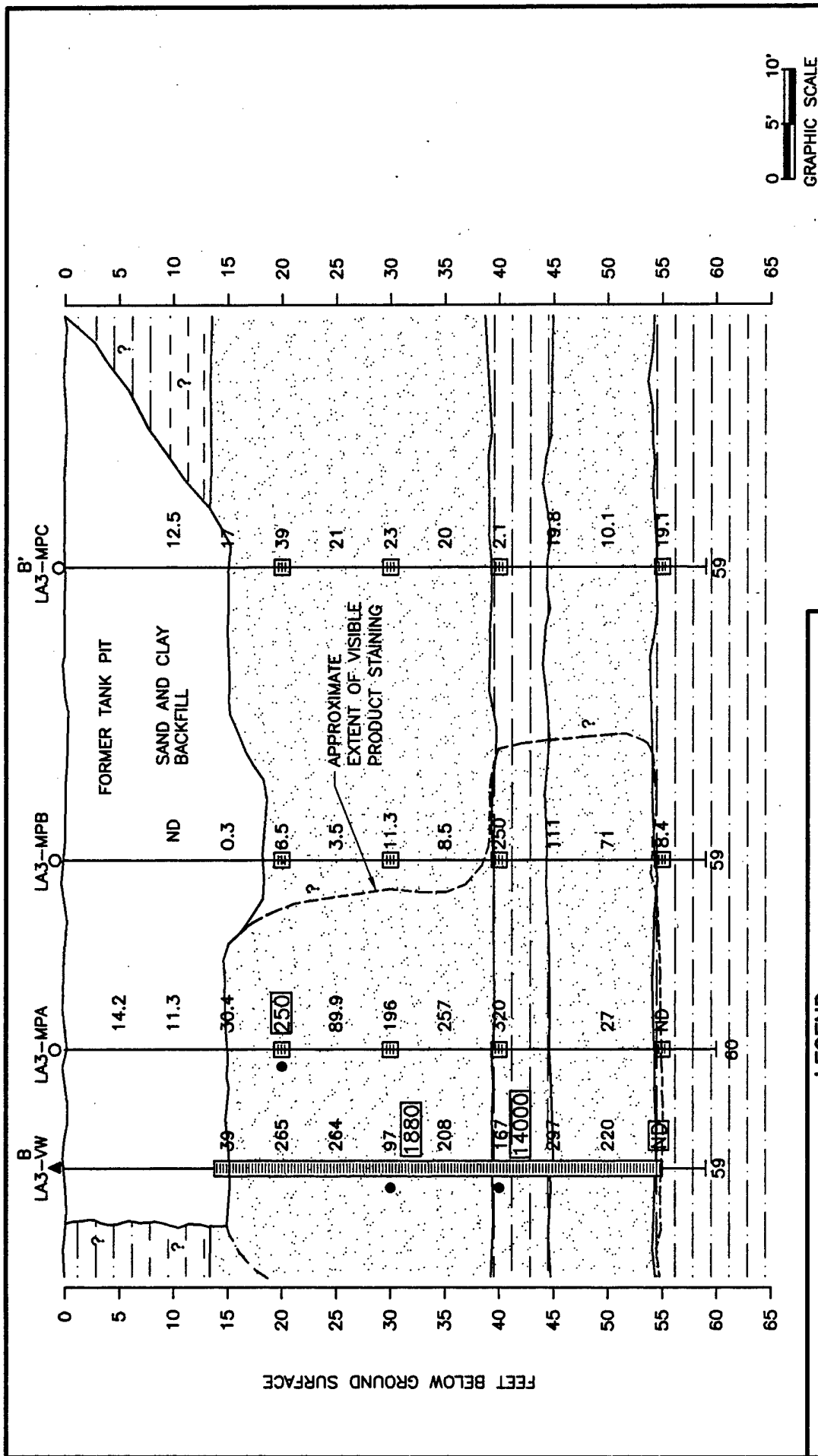
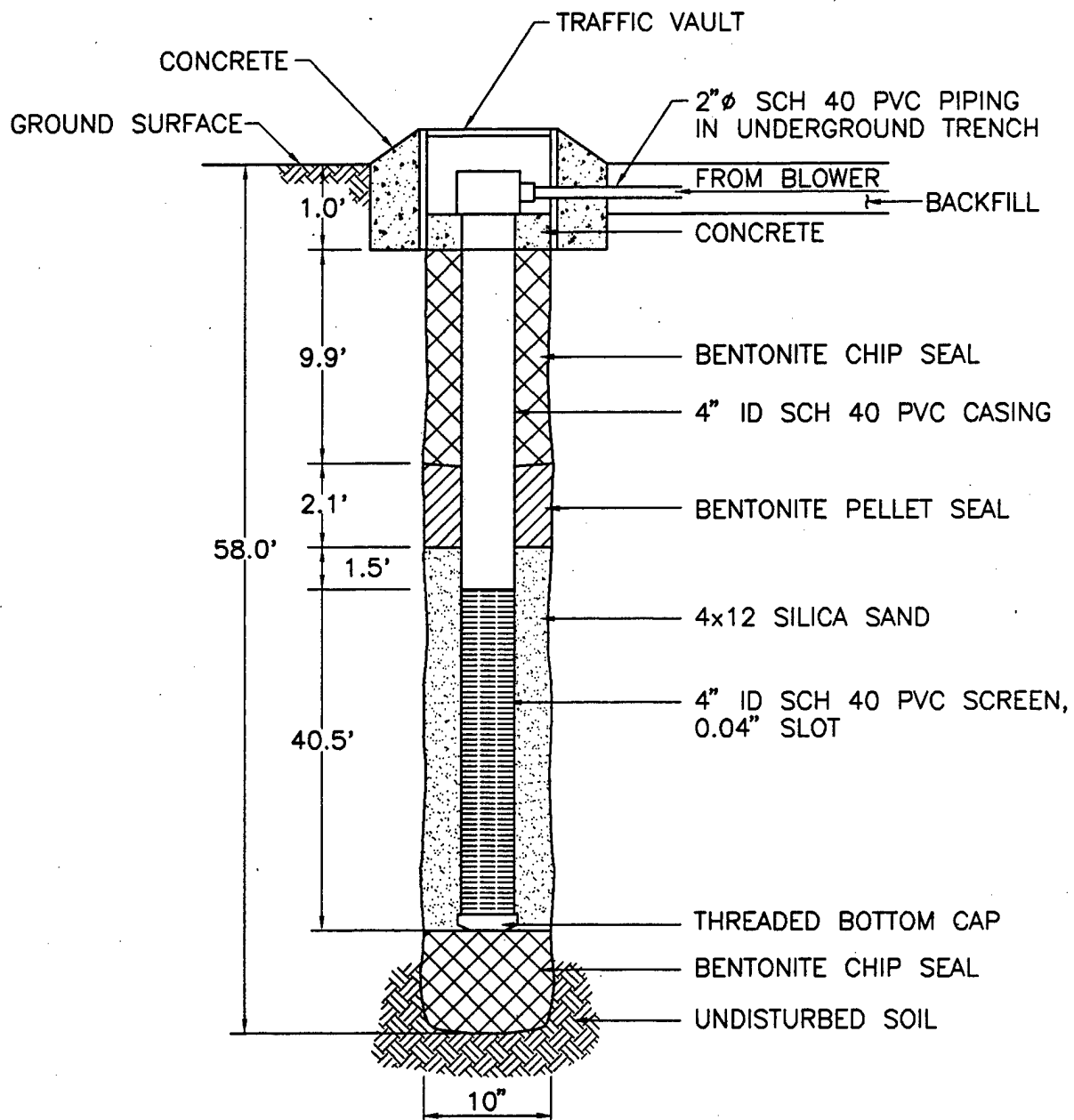


FIGURE 3.2
GEOLOGIC CROSS SECTION B-B'
GATE 3 FORMER HEATING
OIL UST SITE
LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
 La Jolla, California

ES



NOT TO SCALE

FIGURE 3.3
RECORD DRAWING
AIR INJECTION VENT WELL
CONSTRUCTION DETAILS
GATE 3 FORMER
HEATING OIL UST SITE
LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
 La Jolla, California

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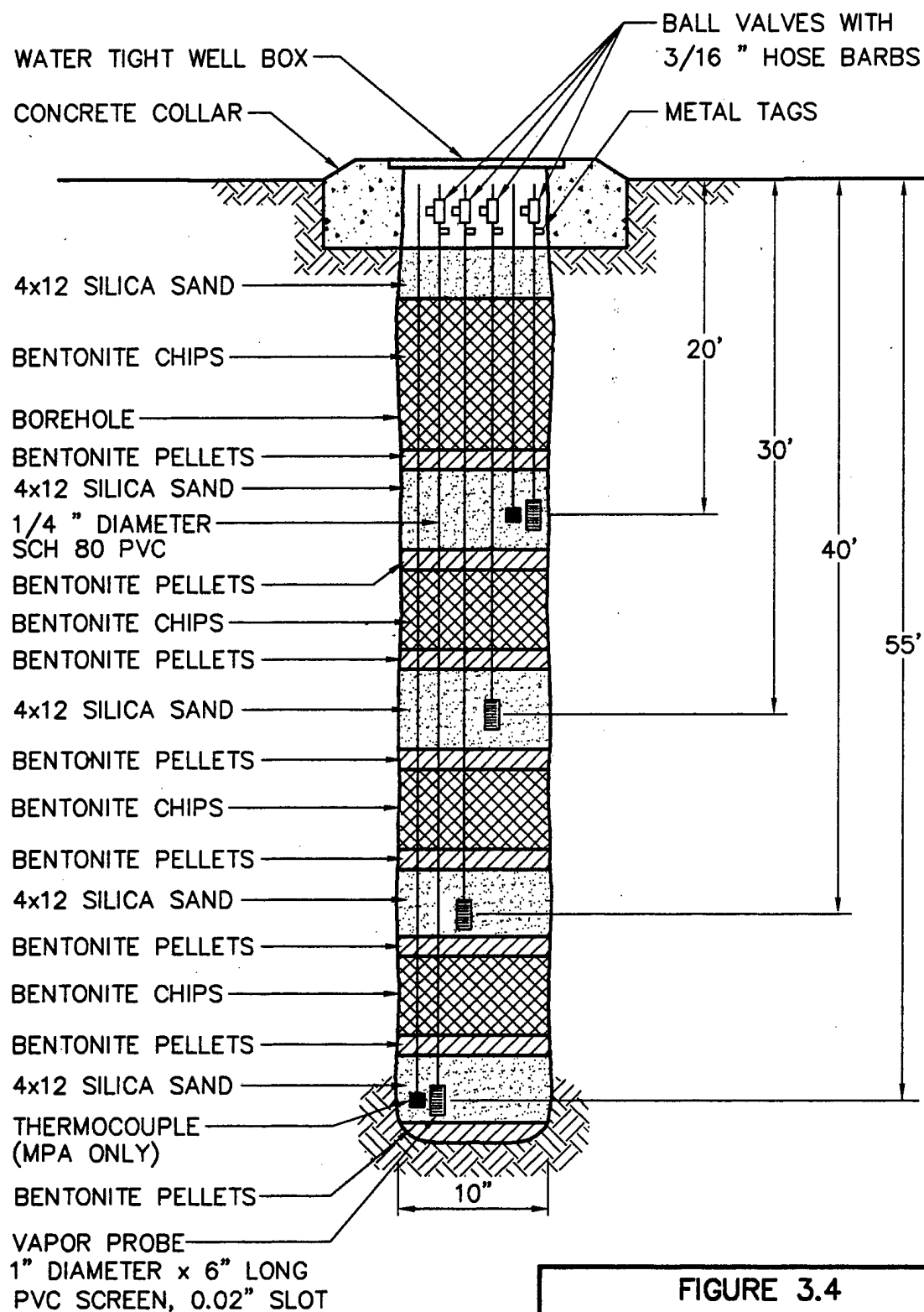
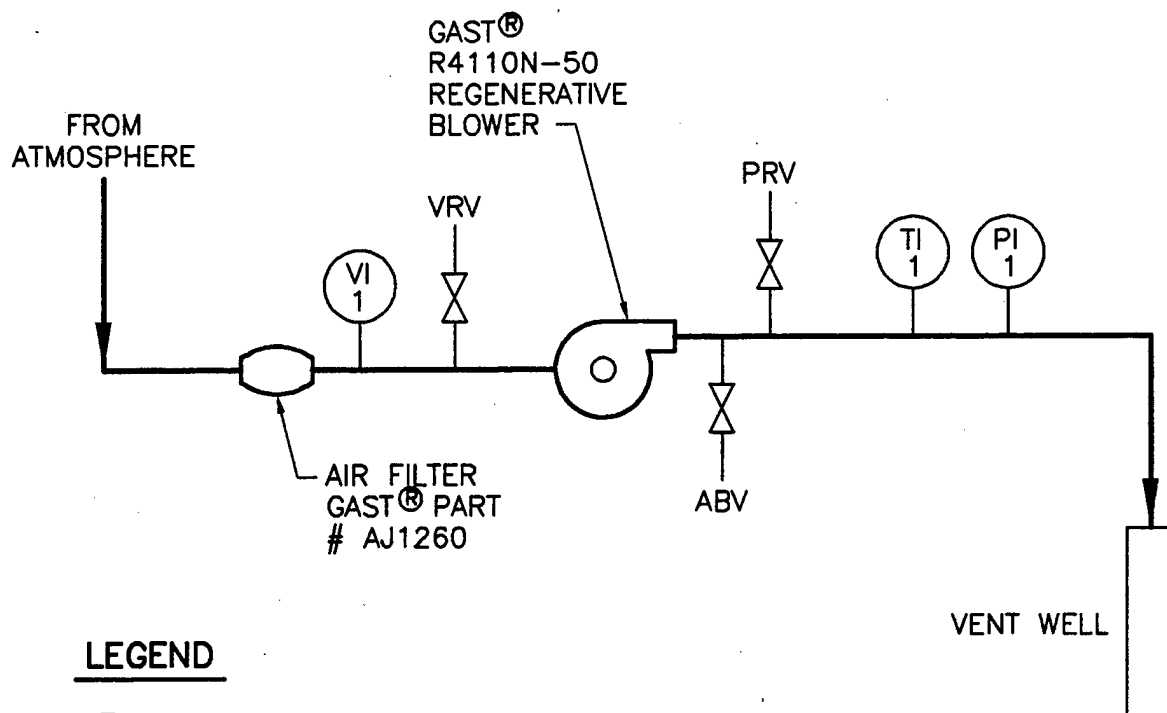


FIGURE 3.4
RECORD DRAWING
MONITORING POINT
CONSTRUCTION DETAILS
GATE 3 FORMER
HEATING OIL UST SITE
LOS ANGELES AFB, CALIFORNIA

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 La Jolla, California

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LEGEND

PI 1 PRESSURE INDICATOR 0"-60" H₂O, GAST® PART # AJ496

TI 1 TEMPERATURE INDICATOR 0°-250°F ASHCROFT®
PART # 30EI 6 OR 025 0/250F

VI 1 VACUUM INDICATOR -60"-0" H₂O, GAST® PART # AJ497

ABV AIR BLEED VALVE 1-1/2" GATE VALVE

PRV PRESSURE RELIEF VALVE 30"-170" H₂O, GAST® PART # AG258

VRV VACUUM RELIEF VALVE -170"-30" H₂O, GAST® PART # AG258

FIGURE 3.5
RECORD DRAWING BLOWER SYSTEM
INSTRUMENTATION DIAGRAM
FOR AIR INJECTION
GATE 3
FORMER HEATING OIL UST SITE
LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
La Jolla, California

ES

3.2 Soil and Soil Gas Sampling Results

3.2.1 Soil Sampling Results

The former 50,000 gallon heating oil tank measured approximately 15' x 60'. Because of its size, considerable amounts of soil were excavated during tank removal operations. The excavation operations included sloping the sides of the excavation and cutting a ramp so equipment could operate in the excavation. The VW and all MPs were located in areas at least partially disturbed by this excavation. Therefore, the exact nature of the native material from ground surface to approximately 15 to 20 feet bgs is not known. It is believed to be similar to the native material encountered in LA2-MPC (clay with some silt and sand). All borings at this site encountered clay-rich fill material to about 20 feet bgs. Below the backfill, medium sand was encountered to approximately 40 feet bgs. In LA3-VW and LA3-MPA, the sand had a strong petroleum odor. The odor diminished in the sand at LA3-MPB, and was not detected at this depth in LA3-MPC. A sandy clay was encountered in all LA3 borings from approximately 40 to 45 feet bgs. This clay appeared to be more permeable than the clay encountered at a similar depth at the Building 241 site, as evidenced by the fact that contamination continued into the sand encountered below 45 feet bgs. This medium to coarse sand extended to approximately 55 feet bgs, where another clay layer was encountered. This clay continued to at least 65 feet bgs, where the deepest boring at the site, LA3-MPA, was terminated. This clay apparently provides an effective barrier against further downward migration of contamination since no evidence of contamination was encountered below 55 feet bgs, the surface of the clay. More detailed hydrogeologic information regarding the site can be found in the hydrogeologic cross section (Figure 3.2) and the geologic boring logs (Appendix B).

Soil samples for laboratory analysis were collected using 18 inch split-spoon samplers with 2 inch diameter brass liners. Soil samples were collected from LA3-VW at 30, 40, and 55 feet bgs, and from LA3-MPA at 20 feet bgs. A sample was collected from each soil type encountered at the site.

Soil samples were shipped via Federal Express® to Pace Laboratory in Novato, California for chemical and physical analysis. Soil samples were analyzed for total recoverable petroleum hydrocarbons (TRPH); total petroleum hydrocarbons as diesel (TPH-D); benzene, toluene, ethylbenzene and xylenes (BTEX); iron; alkalinity; Total Kjeldahl Nitrogen (TKN); moisture content; and grain-size distribution. The results of these analyses are provided in Table 3.1. Chain-of-custody forms are provided in Appendix B.

3.2.2 Soil Gas Sampling Results

Soil gas samples were collected from LA3-MPA at 30 and 55 feet bgs, and from LA3-MPB at 40 feet bgs. Soil gas samples were collected using 3-liter Tedlar® bags and vacuum chambers. After the samples were collected in Tedlar® bags, they were transferred to 1-liter SUMMA® canisters and shipped to the laboratory.

Soil gas samples were shipped via Federal Express® to Air Toxics, Inc., in Rancho Cordova, California, for total volatile hydrocarbons (TVH), BTEX, and methane analysis. The TVH analyses were referenced to jet fuel (Molecular Weight = 156) as there is no suitable analysis for the volatile fraction of heating oil or diesel. The results

Table 3.1

**Soil and Soil Gas Laboratory Analytical Results
Gate 3 Former Heating Oil UST Site
Los Angeles AFB, California**

Analyte (Units) ^a	Sample Location - Depth (Feet Below Ground Surface)			
Soil Gas Hydrocarbons	LA3-MPA-30	LA3-MPA-55	LA3-MPB-40	
TVH ^b (ppmv)	660	1,100	810	
Benzene (ppmv)	ND (0.052)	ND (0.052)	ND (0.052)	
Toluene (ppmv)	ND (0.052)	ND (0.052)	ND (0.052)	
Ethylbenzene (ppmv)	0.52	0.60	0.59	
Xylenes (ppmv)	0.91	1.5	1.1	
Methane (%)	7.9	11	7.6	
Soil Hydrocarbons	LA3-VW-30	LA3-VW-40	LA3-VW-55	LA3-MPA-20
TPH-D ^c (mg/kg)	1,540	2,450	ND (7)	83
TRPH ^d	1,880	14,000	ND (13)	250
Benzene (mg/kg)	ND (0.03)	ND (0.2)	0.0078	ND (0.001)
Toluene (mg/kg)	ND (0.03)	0.9	0.001	ND (0.0003)
Ethylbenzene (mg/kg)	0.11	5.4	0.0009	0.0033
Xylenes (mg/kg)	ND (0.08)	9.1	0.0037	ND (0.0007)
Soil Inorganics				
Iron (mg/kg)	6,730	24,600	31,600	11,800
Alkalinity (mg/kg as Ca CO ₃ ^e)	120	360	120	620
pH (Units)	8.8	8.6	7.3	8.9
TKN ^f (mg/kg)	ND	91	51	170
Phosphates (mg/kg)	420	1,000	2,900	1,300
Soil Physical Parameters				
Moisture (% wt)	4.7	24	25 (26) ^g	8
Gravel (%)	0.0	0.0	1.3	9.0
Sand (%)	97.9	49.5	85.1	71.4
Silt (%)	1.2	29.9	7.5	12.7
Clay (%)	0.9	20.6	6.0	6.9

^a ppmv = Parts Per Million, Volume Per Volume; mg/kg = Milligrams Per Kilogram

^b TVH = Total Volatile Hydrocarbons referenced to Jet Fuel (MW = 156).

^c TPH-D = Total Petroleum Hydrocarbons as Diesel by SW 8015 Modified.

^d TRPH = Total Recoverable Petroleum Hydrocarbons by EPA 418.1.

^e Ca CO₃ = Calcium Carbonate

^f TKN = Total Kjeldahl Nitrogen

^g Surrogate recovery outside established control limits.

NA = Not Analyzed.

ND = None Detected. Method detection limits are in parentheses.

of these analyses are provided in Table 3.1. Chain-of-custody forms are provided in Appendix B.

3.3 Pilot Test Results

3.3.1 Exceptions to Test Protocol Procedures

Procedures described in the protocol document and the site-specific work plan (Part I) were used to complete the pilot test at this site. Exceptions to the Part I work plan included extending the total depths of the VW and MPs due to deeper than expected soil contamination. For this same reason, MPs were located further away from the VW than described in the Part I work plan. Because of high concentrations reported during other site investigations, methane analysis was added to the soil gas sample analytical parameters. Because of the similarity in composition of diesel and heating oil, soil samples were analyzed for TPH as diesel, as well as those analytes described in the protocol document.

3.3.2 Initial Soil Gas Chemistry

Prior to initiating air injection for the respiration test, the VW and the MP were purged, and initial oxygen, carbon dioxide, and TVH concentrations were sampled using portable gas analyzers, as described in the technical protocol document. Table 3.2 summarizes the initial soil gas chemistry at the site. The results strongly indicate that biological fuel degradation has depleted the oxygen supply in the vadose zone. The VW and all MPs installed through the former tank bed contained oxygen levels of 0.0 to 9.0 percent. Carbon dioxide was present at elevated concentrations, ranging from 2.5 to 12.0 percent. Exceptionally high TVAH readings of over 20,000 ppmv (off-scale) were recorded at most MP depths during initial soil gas monitoring. Soil gas samples were reanalyzed with the Gas Tech® TVH meter in the "no methane response" mode. Readings with no methane response were significantly lower, indicating the presence of methane. Soil gas sample analysis (Table 3.1) indicated the presence of natural methane ranging from 7.6 to 11 percent.

3.3.3 *In Situ* Respiration Rates

An *in situ* respiration test was conducted at the site according to protocol document procedures. Four 1 cfm pumps were used to inject air into MPA-20, MPA-30, MPA-40, and MPA-55 for 18.5 hours. Helium, at a concentration of between 3 and 6.3 percent was also injected into each point. Oxygen concentrations at each MPA point were increased to at least 19.2 percent. After air injection ceased, changes in soil gas composition were monitored over time. Oxygen, carbon dioxide, TVH, and helium concentrations were measured over a period of between 51 to 114 hours following the air injection period. The observed rates of oxygen utilization were then used to estimate the aerobic fuel degradation rates at the site. Figures 3.6 through 3.8 present the results of *in situ* respiration testing at the site, and Table 3.3 provides a summary of the observed oxygen utilization rates. The oxygen utilization rates observed in contaminated soils ranged from 0.00235 percent per minute (%/min) to 0.0076 %/min. Helium levels remained relatively constant when compared to oxygen utilization, indicating that diffusions or MP leaks were not contributing to oxygen loss.

An estimated 200 to 1,450 milligrams (mg) of fuel per kilogram (kg) of soil can be degraded each year. This value is the range of the fuel consumption rates calculated

Table 3.2
Initial Soil Gas Chemistry
Gate 3 Former Heating Oil UST Site
Los Angeles AFB, California

Sample Location	Depth (ft bgs)	O ₂ (percent)	CO ₂ (percent)	TVH-Field (ppmv) ^a	TVH-Field (ppmv) ^b	TVH-Lab (ppmv) ^c	Temperature °F
LA3-VW	14.5-55	5.2	6.0	> 20,000	560	NA	NA
LA3-MPA-20	20	0.0	5.7	> 20,000	230	NA	77.1
LA3-MPA-30	30	0.0	4.8	19,600	3,200	660	NA
LA3-MPA-40	40	2.5	2.5	20,000	320	NA	NA
LA3-MPA-55	55	9.0	5.0	> 20,000	440	1,100	72.8
LA3-MPB-20	20	0.0	10.9	> 20,000	340	NA	NA
LA3-MPB-30	30	0.0	10.2	> 20,000	660	NA	NA
LA3-MPB-40	40	0.0	9.8	> 20,000	600	810	NA
LA3-MPB-55	55	1.5	9.5	> 20,000	800	NA	NA
LA3-MPC-20	20	0.0	12.0	> 20,000	660	NA	NA
LA3-MPC-30	30	0.0	11.5	> 20,000	1,600	NA	NA
LA3-MPC-40	40	0.0	3.0	NA	580	NA	NA
LA3-MPC-55	55	0.0	10.5	> 20,000	1,100	NA	NA

^a Total hydrocarbon analyzer field screening results.

^b Total hydrocarbon analyzer field screening results. No Methane Response.

^c Laboratory results referenced to Jet Fuel (MW = 156).

NA = Not Analyzed.

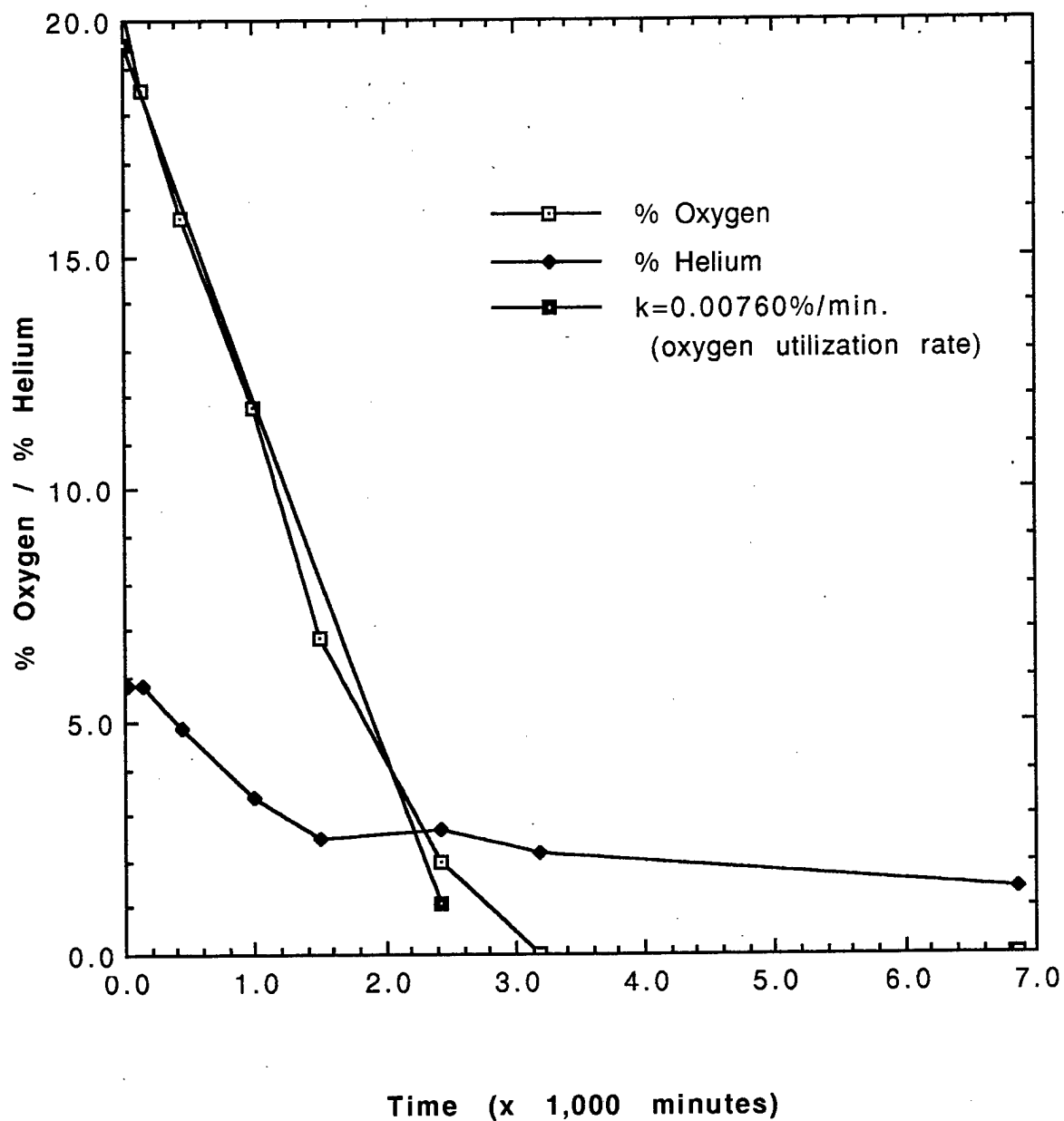


FIGURE 3.6
Respiration Test
LA3-MPA20'
Gate 3
Former Heating Oil UST Site

Engineering-Science, Inc.

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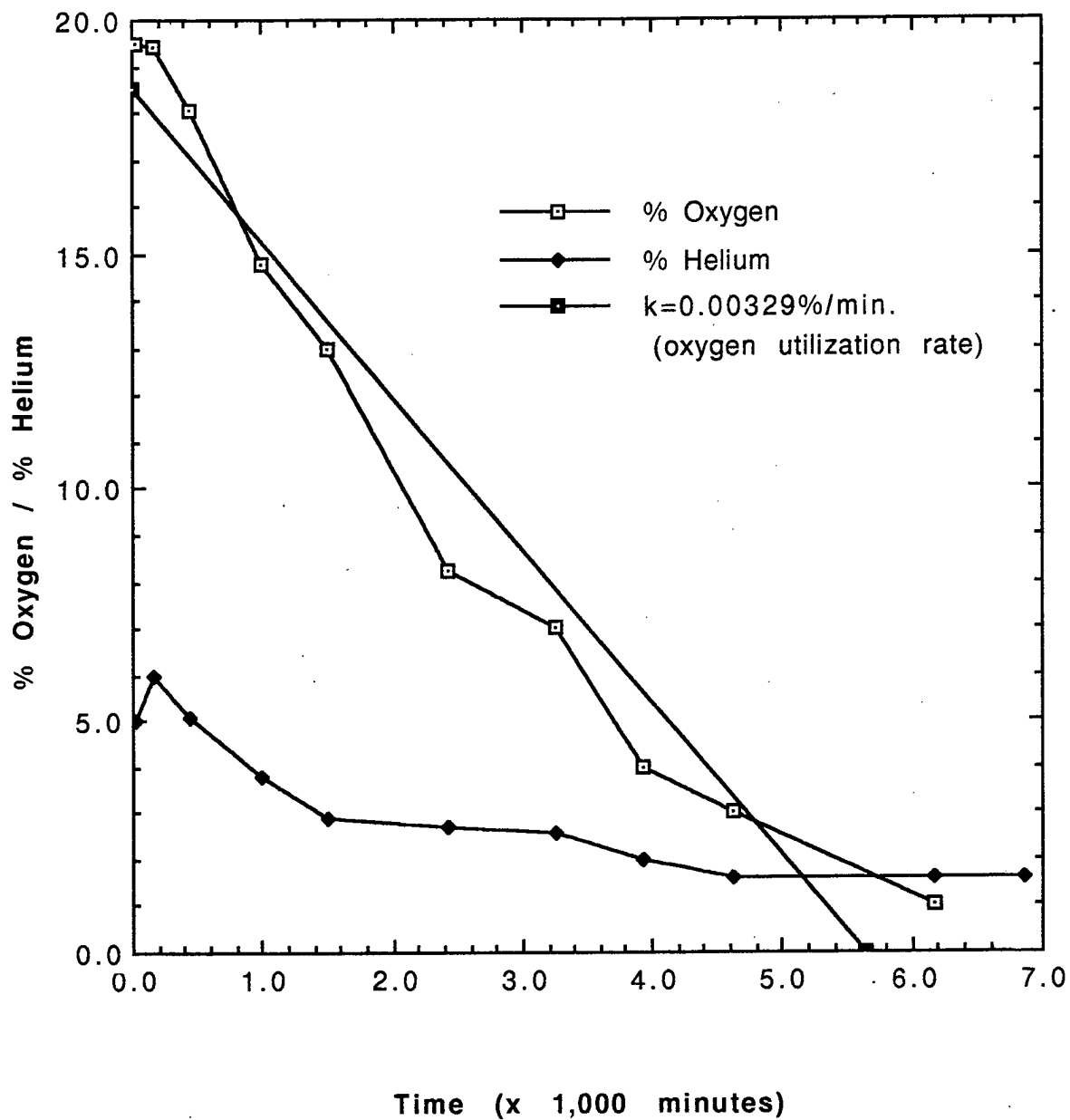


FIGURE 3.7
Respiration Test
LA3-MPA30'
Gate 3
Former Heating Oil UST Site

Engineering-Science, Inc.

ES

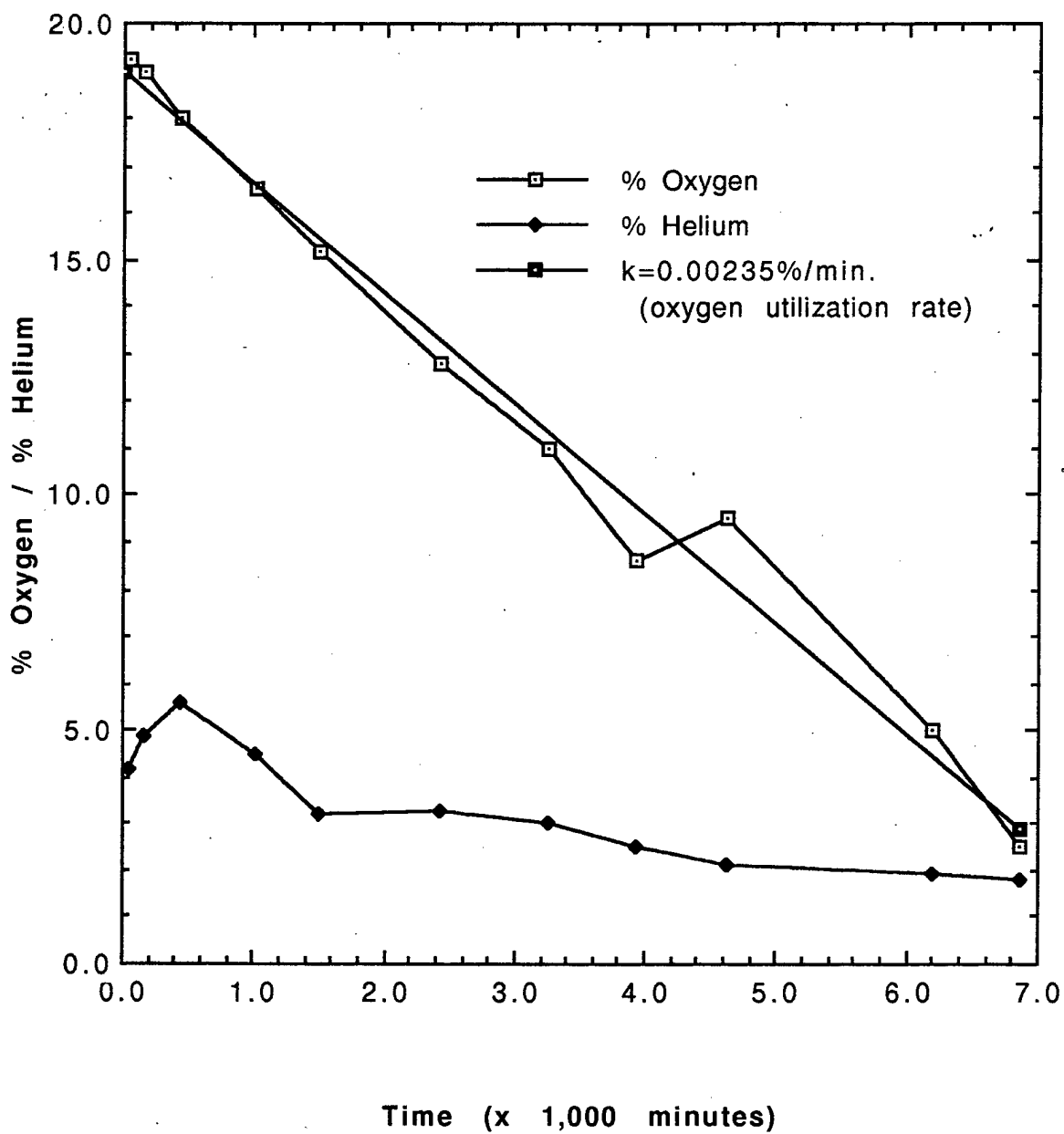


FIGURE 3.8
Respiration Test
LA3-MPA40'
Gate 3
Former Heating Oil UST Site

Engineering-Science, Inc.

ES

Table 3.3
Oxygen Utilization Rates
Gate 3 Former Heating Oil UST Site
Los Angeles AFB, California

MP	O ₂ Loss ^(a) (percent)	Test Duration (min.)	O ₂ Utilization ^(a) Rate (percent/min)	Hydrocarbon Degradation Rate (mg/kg/yr)
LA3-MPA-20	18.43	2425	0.0076	1450
LA3-MPA-30	16.77	6177	0.0033	1010
LA3-MPA-40	16.11	6865	0.0024	200

^(a) Values based on linear regression (Figure 3.6 through 3.8).

for LA3-MPA-20, LA3-MPA-30, and LA3-MPA-40. Some oxygen uptake was observed in LA3-MPA-55, but the results were inconclusive. The relatively low rate for LA3-MPA-40 could be due to the high (24 percent) moisture content found in the clay at this depth. The high moisture content would reduce the air-filled porosity and, therefore, the ability of oxygen to diffuse through the contaminated soil. The point-specific fuel consumption rates were calculated using observed oxygen utilization rates, and estimated air-filled porosity ranging from 0.043 to 0.152 liters of air/kg of soil, and a conservative ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded.

3.3.4 Air Permeability

An air permeability test was conducted at the site according to protocol document procedures. Air was injected into the VW for approximately 21 hours at a rate of approximately 40 cubic feet per minute (cfm) and an average pressure of approximately 3 inches of water. The pressure responses at each MP are listed in Table 3.4. The pressure measured at most MPs increased gradually for the first 30 to 40 minutes after which pressures remained relatively stable. Because of the relatively stable readings, monitoring stopped after 4 hours. The dynamic method of determining air permeability is coded in the HyperVentilate® model that was used to calculate soil gas permeability values ranging from 34 darcys to 162 darcys for this site. A minimum pressure influence of 60.5 feet was observed at all but 40 feet bgs based on readings from MPC.

3.3.5 Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the central VW during pilot testing is the primary design parameter for full-scale bioventing systems. Optimization of full-scale and multiple VW systems requires pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 3.5 describes the change in soil gas oxygen levels that occurred after 21 hours of air injection during the air permeability test at the site. This air injection period at 40 cfm produced a significant increase in soil gas oxygen levels at a distance of at least 34 feet from the central VW at the 40 and 55 foot depths in MPB, and a slight increase at the 20 and 30 foot depths in MPC, 60.5 feet away from the central VW. Based on measured pressure response, which is an indicator of long-term oxygen transport, it is anticipated that the radius of influence for a long-term bioventing system at this site will exceed 60 feet at all depths. Monitoring during the extended pilot test at this site will better define the effective treatment radius.

3.3.6 Potential Air Emissions

Site contamination consisted of heating oil, a compound of relatively low volatility. The maximum field head space reading observed at the site was 320 ppm. The maximum concentration of TVH and benzene compounds detected in soil gas samples was 1,100 ppmv and non-detect (ND), respectively. Also, due to the methane detected at the site, air injection rates for the long-term pilot test were reduced to 35 cfm. The reduced flow rate will help prevent the unwanted migration of methane, as well as reduce the potential for volatile emissions. The long-term potential for air emissions from full-scale bioventing operations at this site is low. Initial emissions should be

Table 3.4

**Pressure Response (Inches of Water) During Air Permeability Test
Gate 3 Former Heating Oil UST Site
Los Angeles AFB, California**

Location Depth (ft. bgs)	MPA				MPB				MPC			
	20	30	40	55	20	30	40	55	20	30	40	55
Elapsed Time (min)	(Questionable readings at MPA. Gages recalibrated at T = 20 min.)											
0					0	0	0	0	0	0	0	0
1					0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
2					0.1	0.1	0.2	0.3	0.0	0.0	0.0	0.05
3					0.15	0.15	0.2	0.35	0.0	0.0	0.0	0.1
4					0.2	0.2	0.25	0.4	0.05	0.0	0.0	0.1
5					0.2	0.2	0.25	0.45	0.05	0.05	0.0	0.2
6					0.25	0.25	0.3	0.5	0.1	0.1	0.0	0.2
7					0.3	0.3	0.35	0.55	0.1	0.15	0.0	0.3
8					0.3	0.3	0.35	0.6	0.1	0.15	0.0	0.3
9					0.35	0.35	0.4	0.65	0.15	0.2	0.0	0.35
10					0.35	0.35	0.4	0.65	0.15	0.2	0.0	0.35
12					0.4	0.4	0.45	0.7	0.2	0.2	0.0	0.4
14					0.4	0.4	0.5	0.75	0.2	0.25	0.0	0.45
16					0.45	0.45	0.5	0.8	0.25	0.25	0.0	0.5
18					0.5	0.5	0.55	0.85	0.25	0.3	0.0	0.55
20	1.0	0.9	0.9	1.3	0.5	0.5	0.55	0.9	0.25	0.3	0.0	0.55
22	1.0	0.9	0.9	1.3	0.5	0.5	0.55	0.9	0.25	0.3	0.0	0.6
24	1.0	0.9	0.9	1.4	0.5	0.5	0.6	0.95	0.3	0.35	0.0	0.65
26	1.0	0.9	0.9	1.4	0.55	0.55	0.6	1.0	0.3	0.35	0.0	0.65
28	1.0	0.9	0.9	1.4	0.55	0.55	0.65	1.0	0.35	0.4	0.0	0.7
30	1.0	1.0	1.0	1.4	0.55	0.6	0.65	1.0	0.35	0.4	0.0	0.7
33	1.0	1.0	1.0	1.4	0.6	0.6	0.65	1.0	0.35	0.4	0.0	0.75
36	1.0	1.0	1.0	1.4	0.6	0.6	0.65	1.05	0.35	0.4	0.0	0.75
39	1.0	1.0	1.0	1.4	0.6	0.6	0.7	1.1	0.4	0.4	0.0	0.8
42	1.0	1.0	1.0	1.5	0.6	0.6	0.7	1.1	0.4	0.45	0.0	0.8
45	1.0	1.0	1.0	1.5	0.6	0.6	0.7	1.1	0.4	0.45	0.0	0.8
48	1.0	1.0	1.0	1.5	0.6	0.6	0.7	1.1	0.4	0.45	0.0	0.8
51	1.0	1.0	1.0	1.5	0.6	0.6	0.65	1.1	0.4	0.45	0.0	0.8
54	1.0	1.0	1.0	1.5	0.6	0.6	0.65	1.1	0.35	0.4	0.0	0.85
57	1.0	1.0	1.0	1.5	0.6	0.6	0.7	1.1	0.4	0.45	0.0	0.85

Table 3.4 (Cont.)
Pressure Response (Inches of Water) During Air Permeability Test
Gate 3 Former Heating Oil UST Site
Los Angeles AFB, California

<u>Location</u>	<u>MPA</u>				<u>MPB</u>				<u>MPC</u>			
Depth (ft. bgs)	20	30	40	55	20	30	40	55	20	30	40	55
Elapsed Time (min)												
60	1.0	1.0	1.1	1.5	0.65	0.65	0.7	1.15	0.4	0.45	0.0	0.9
75	1.1	1.0	1.1	1.6	0.7	0.65	0.75	1.2	0.45	0.5	0.0	0.95
90	1.1	1.0	1.15	1.6	0.7	0.7	0.75	1.25	0.5	0.5	0.0	1.0
150	1.1	1.0	1.15	1.65	0.7	0.7	0.75	1.3	0.5	0.5	0.0	1.0
180 ^a	1.0	1.0	1.05	1.55	0.7	0.6	0.65	1.2	0.4	0.45	0.0	0.95
240 ^a	0.9	0.9	0.95	1.45	0.5	0.5	0.55	1.1	0.3	0.35	0.0	0.80

^a Readings taken near dusk, temperature dropping.

Table 3.5

Influence of Air Injection Vent Well on Monitoring Point Oxygen Levels
Gate 3 Former Heating Oil UST Site
Los Angeles AFB, California

Sample Location	Distance from VW (ft)	Depth (ft. bgs)	Initial O ₂ (percent)	Final O ₂ ^a (percent)
LA3-MPA-20	16	20	0.0	3.5
LA3-MPA-30	16	30	0.0	20.0
LA3-MPA-40	16	40	0.0	19.0
LA3-MPA-55	16	55	0.0	20.6
LA3-MPB-20	33.5	20	0.0	0.0
LA3-MPB-30	33.5	30	0.0	0.0
LA3-MPB-40	33.5	40	0.0	15.2
LA3-MPB-55	33.5	55	0.0	18.5
LA3-MPC-20	60.5	20	0.0	0.5
LA3-MPC-30	60.5	30	0.0	1.0
LA3-MPC-40	60.5	40	NA	NA
LA3-MPC-55	60.5	55	0.0	0.0

^a Readings taken after 18 hours of air injection during air permeability test.
NA = Not analyzed (could not sample).

minimal because accumulated vapors will move slowly outward from the air injection point and will be biodegraded as they move horizontally through the soil. Any upward migration would tend to be retarded by the clay layer from 0 to 15 feet bgs. During the air permeability test, air was injected at 40 cfm. Health and safety hydrocarbon-analyzer air monitoring of the breathing zone at the site indicated that total hydrocarbon concentrations did not increase above 1 ppmv during the initial days of the test. The initial day of bioventing generally produces the highest potential for emissions as the first pore volume of soil gas is replaced.

3.4 Recommendations

Initial bioventing tests at this site indicate that oxygen had been depleted in the contaminated soils, and that air injection is an effective method of stimulating aerobic fuel biodegradation. AFCEE has recommended that air injection continue at this site to determine the long-term radius of oxygen influence and the effects of time, available nutrients, and changing temperatures on fuel biodegradation rates.

A 1 horsepower regenerative blower has been installed at the site for continuous air injection. In June 1994, ES will return to the site to sample and analyze the soil gas and conduct a repeat respiration test. In December 1994, a final respiration test will be conducted, and soil and soil gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

4.0 BUILDING 125 FORMER HEATING OIL UST SITE

A pilot test was conducted at this site when shallow groundwater was encountered at the scheduled Building 110 site. Available field notes from the past tank removal operation indicated that the Building 125 former heating oil UST site could be a potential alternative. In early 1993, a 3,400 gallon heating oil UST was removed. One of the two soil samples collected from the tank bed excavation had 1,600 mg/kg of TPH as diesel (EPA 8015 modified for diesel) and 4,300 mg/kg of TRPH (EPA 418.1). This sample also had ethylbenzene and xylene contamination of 82 g/kg and 180 g/kg, respectively.

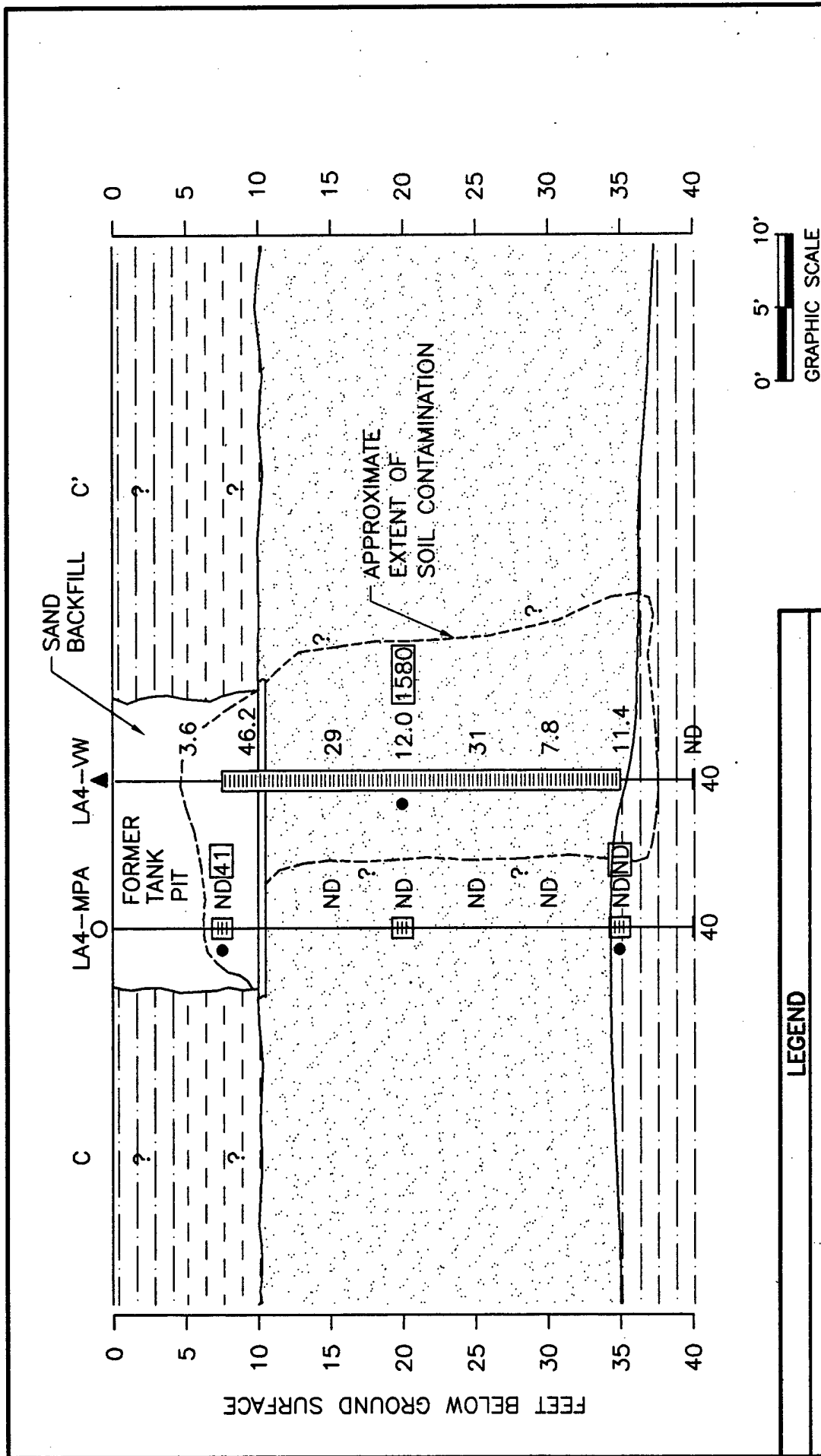
4.1 Pilot Test Design and Construction

Installation of an air injection vent well (VW) and one vapor monitoring point (MP) at the Building 125 former heating oil UST site (designed LA4) was completed on 8 July 1993. Drilling services were provided by Tonto Environmental Drilling of Fontana, California. Well installation and soil sampling were directed by ES geologists Mr. Larry Dudus and Mr. Chris Pluhar. The following sections describe the final design and installation of the bioventing pilot test system at this site.

One VW (LA4-VW), one MP, and a blower unit were installed at the site. Figures 4.1 and 4.2, respectively, depict the location of, and a hydrogeologic cross section for, the VW and MP completed at the site.

4.1.1 Air Injection Vent Well

The air injection VW was installed following procedures described in the AFCEE protocol document. Figure 4.3 shows construction details for LA4-VW.



123 FIELD PID READINGS (PPMV)

MONITORING POINT SCREENED INTERVAL

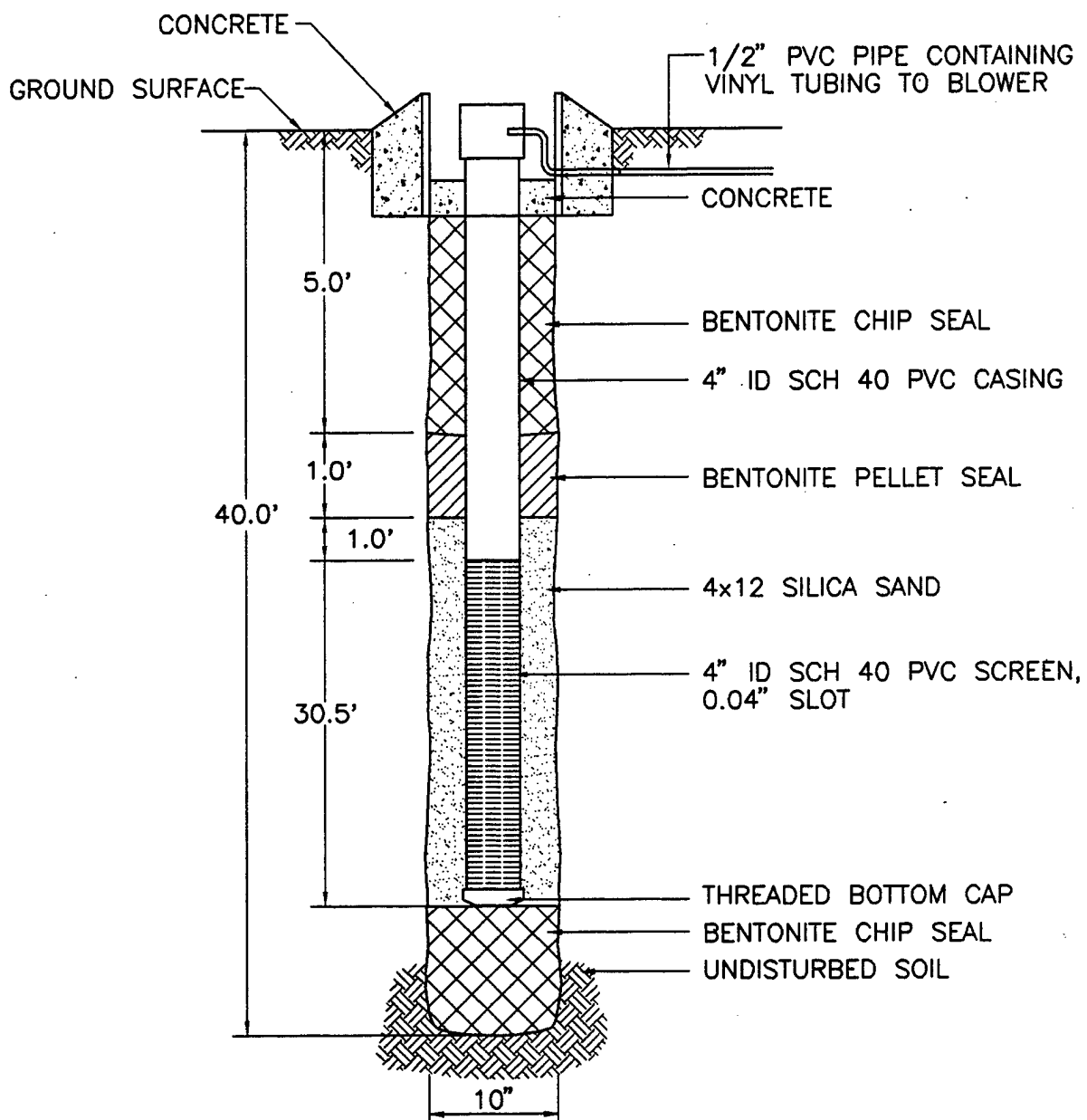
LABORATORY RESULTS FOR TOTAL RECOVERABLE PETROLEUM HYDROCARBONS BY EPA 418.1 (MG/KG)

VENT WELL SCREENED INTERVAL

FIGURE 4.2
 GEOLOGIC CROSS SECTION C-C'
 BUILDING 125 FORMER HEATING
 OIL UST SITE
 LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
 La Jolla, California

ES



NOT TO SCALE

FIGURE 4.3
RECORD DRAWING
AIR INJECTION VENT WELL
CONSTRUCTION DETAILS
BUILDING 125 FORMER
HEATING OIL UST SITE
LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
 La Jolla, California

ES

The VW was installed through the former tank bed in hydrocarbon-contaminated soil. The VW was constructed using 4 inch diameter, Schedule 40 PVC casing, with 30 feet of 0.04 inch slotted PVC screen installed from 7 to 37 feet bgs. The annular space between the well casing and borehole was filled with 4 x 12 silica sand from approximately 37.5 feet bgs to 1 foot above the well screen. Approximately 1 foot of bentonite pellets was placed above the sand and hydrated in place. Approximately 4 feet of bentonite chips were placed on top of the pellets. The top of the well was completed with a flush-mounted metal well vault set in a 2.5 x 2.5 x .5 foot concrete pad. The blower injects air through vinyl tubing encased in 1/2 inch PVC piping, which connects to the capped PVC well casing at a brass 3/16 inch hose barb.

4.1.2 Monitoring Points

Because of the relatively small amount of soil contamination detected at the site, only 1 MP was installed. The screens for MPA were installed at 7, 20, and 35 foot depths. LA4-MPA was constructed as shown in Figures 4.2 and 4.4. Each MP monitoring interval was constructed using a 6 inch section of 1 inch diameter 0.02 inch slotted PVC well screen and a 0.25 inch diameter Schedule 80 PVC riser pipe extending to the ground surface. At the top of each riser, a ball valve and a 3/16 inch hose barb were installed. The top of each MP was completed with a flush-mounted metal well vault set in a concrete base. Thermocouples were installed at the 7 and 35 foot depths to measure soil temperature variations.

4.1.3 Blower Unit

During the initial pilot test, 3 portable Gast® 1 cfm pumps were used to deliver air to the VW. For the extended test, a Gast® rotary vane pump was installed in a small shed which is located 10 feet to the southeast of LA4-VW. The fixed unit is energized by a 120 volt, single-phase, 20-amp power line from a breaker box in Building 125. The configuration, instrumentation, and specifications for this blower system are shown on Figure 4.5. The blower is currently injecting air at a flow rate of approximately 2.3 cfm for the extended pilot test. After blower installation and startup, ES engineers provided an O&M manual, including maintenance instructions, equipment specifications, and monitoring forms, to base personnel. A copy of the O&M manual is provided in Appendix A.

4.2 Soil and Soil Gas Sampling Results

4.2.1 Soil Sampling Results

LA4-VW and LA4-MPA were drilled through the former tank bed. Medium sand was encountered from ground surface to approximately 37 feet bgs at both locations. An 8 inch thick concrete slab was encountered at 10 feet bgs. With the exception of the sample taken at 10 feet bgs, the sand from LA4-VW had a slight petroleum odor. The 10 foot bgs sample directly below the concrete slab had a strong petroleum odor. All soil samples from LA4-MPA had no field evidence of contamination. At 35 to 37 feet bgs, a clay was encountered. The clay extended to at least 40 feet.

Unlike the other sites at the base, backfill material at this site consisted of sand instead of clay. Because the VW and MP at this site did not penetrate native material between 0 and 10 feet bgs, it is not known whether imported sand was used as backfill or that the near-surface clay observed at the other sites is absent. More detailed

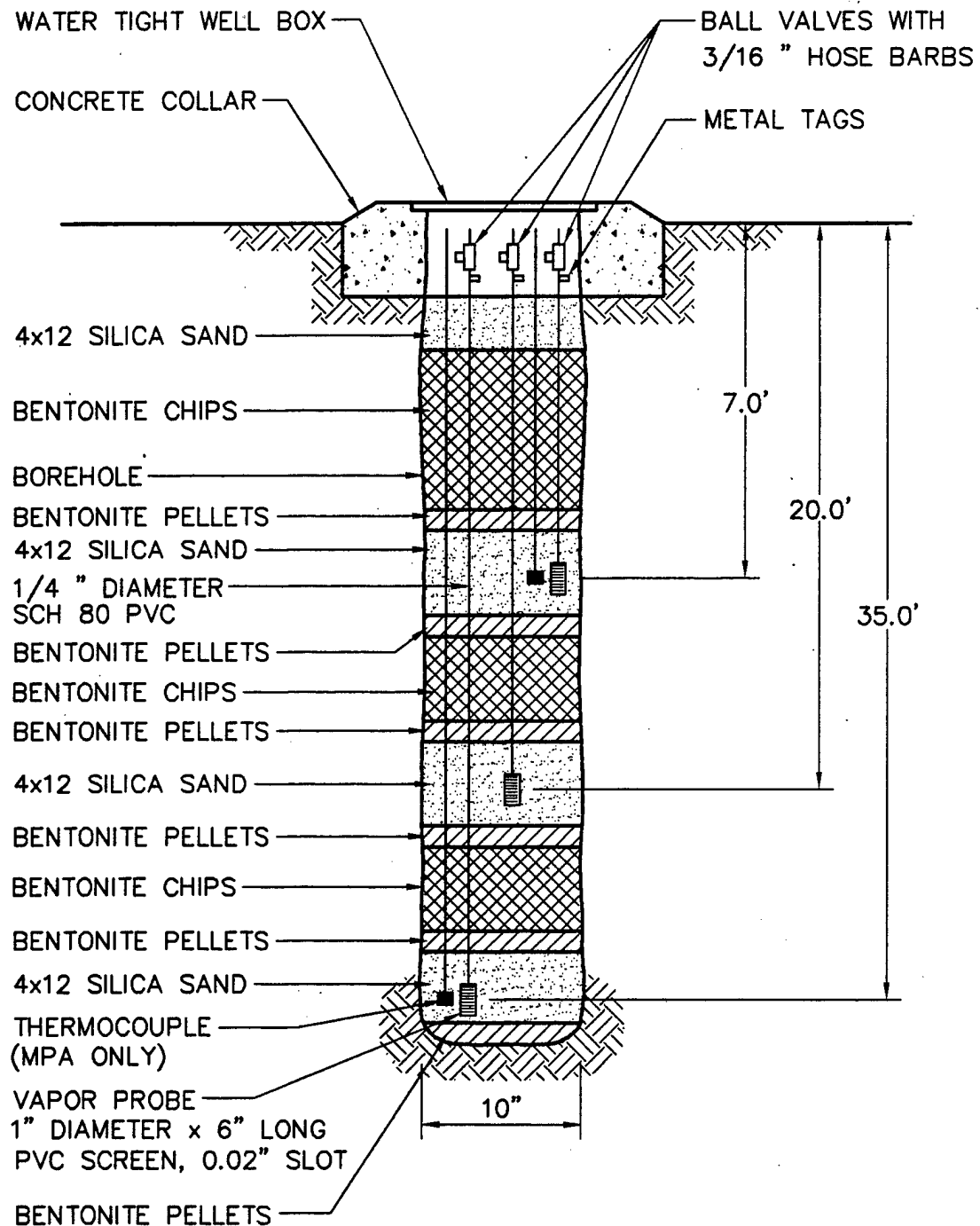
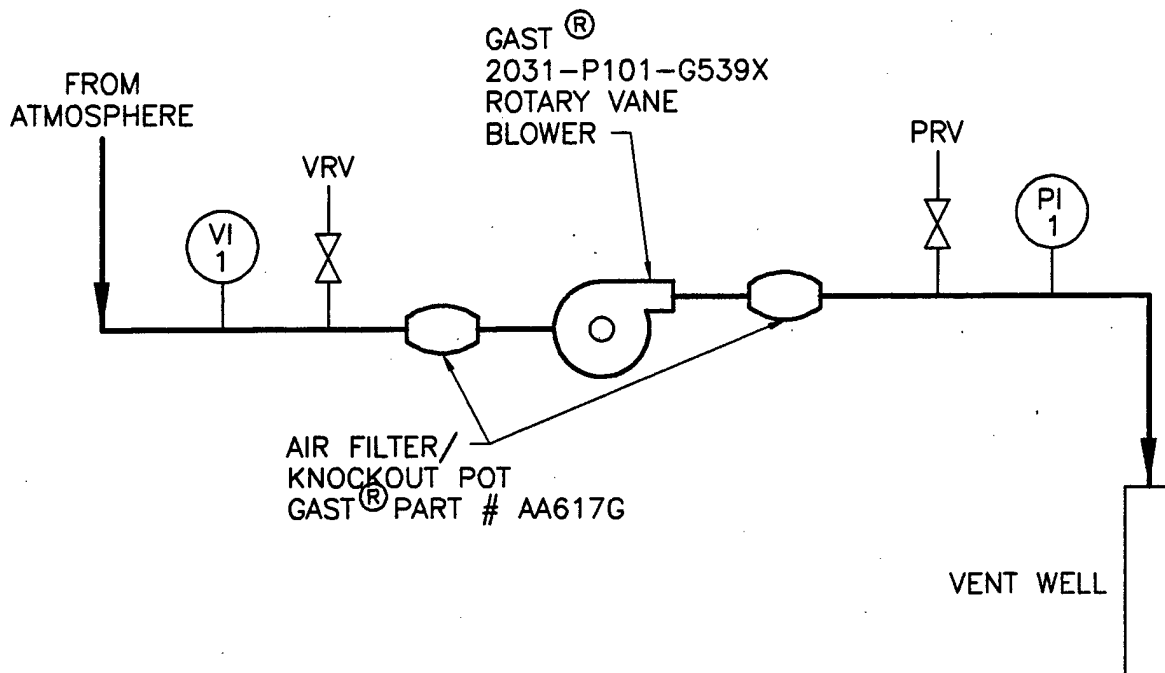


FIGURE 4.4
RECORD DRAWING
MONITORING POINT
CONSTRUCTION DETAILS
BUILDING 125 FORMER
HEATING OIL UST SITE
LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
 La Jolla, California

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LEGEND

- (PI 1) PRESSURE INDICATOR 0-30 PSI GAST® PART # AA6440
 (VI 1) VACUUM INDICATOR -30" -0" Hg GAST® PART # AA640
 PRV PRESSURE RELIEF VALVE 2-30 PSI GAST® PART # AA600
 VRV VACUUM RELIEF VALVE -27" -5" Hg GAST® PART # AA840

FIGURE 4.5
RECORD DRAWING BLOWER SYSTEM
INSTRUMENTATION DIAGRAM
FOR AIR INJECTION
BUILDING 125
FORMER HEATING OIL UST SITE
LOS ANGELES AFB, CALIFORNIA

ENGINEERING-SCIENCE, INC.
 La Jolla, California

ES

hydrogeologic information regarding the site can be found in the hydrogeologic cross section (Figure 4.2) and the geologic boring logs (Appendix B).

Soil samples for laboratory analysis were collected using an 18 inch split-spoon sampler with 2 inch diameter brass liners. Soil samples were collected from LA4-VW at 20 feet bgs, and from LA4-MPA at 7 and 35 feet bgs. The samples from LA4-MPA were collected to confirm the absence of contamination and, thus, help characterize the site.

Soil samples were shipped via Federal Express® to the Pace laboratory in Novato, California for chemical and physical analysis. Soil samples were analyzed for total recoverable petroleum hydrocarbons (TRPH); total petroleum hydrocarbons as diesel (TPH-D); benzene, toluene, ethylbenzene and xylenes (BTEX); iron; alkalinity; Total Kjeldahl Nitrogen (TKN); moisture content; and grain-size distribution. The results of these analyses are provided in Table 4.1. Chain-of-custody forms are provided in Appendix B.

4.2.2 Soil Gas Sampling Results

One soil gas sample was collected from LA4-VW. The sample was collected using a 3-liter Tedlar® bag and vacuum chamber. The sample was transferred to a 1-liter SUMMA® canister and shipped to the laboratory.

The soil gas sample was shipped via Federal Express® to Air Toxics, Inc., in Rancho Cordova, California, for total volatile hydrocarbons (TVH), BTEX, and methane analysis. The TVH analysis was referenced to jet fuel (Molecular Weight = 156) as there is no suitable analysis for heating oil or diesel. The results of these analyses are provided in Table 4.1. Chain-of-custody forms are provided in Appendix B.

4.3 Pilot Test Results

4.3.1 Exceptions to Test Protocol Procedures

Procedures described in the protocol document and the site-specific work plan (Part I) for the other sites were used to complete the pilot test at this site. An exception to the protocol document was the installation of one MP instead of the usual three. Only one MP was installed due to the very limited extent of soil contamination. Also, because of the apparent lack of contamination in MPA, the *in situ* respiration test was conducted at the VW.

4.3.2 Initial Soil Gas Chemistry

Prior to initiating air injection for the respiration test, the VW and the MP were purged, and initial oxygen, carbon dioxide, and TVH concentrations were sampled using portable gas analyzers, as described in the technical protocol document. Table 4.2 summarizes the initial soil gas chemistry at the site. The results strongly indicate that biological fuel degradation has depleted the oxygen supply in the vadose zone adjacent to LA4-VW. Soil gas samples from LA4-VW and MPA contained 0 percent oxygen and carbon dioxide concentrations of between 6.0 and 11.2 percent.

Table 4.1

**Soil and Soil Gas Laboratory Analytical Results
Building 125 Former Heating Oil UST Site
Los Angeles AFB, California**

Analyte (Units) ^a	Sample Location - Depth (Feet Below Ground Surface)		
Soil Gas Hydrocarbons	LA4-VW		
TVH ^b (ppmv)	2,200		
Benzene (ppmv)	ND (0.051)		
Toluene (ppmv)	ND (0.051)		
Ethylbenzene (ppmv)	0.089		
Xylenes (ppmv)	0.20		
Methane (%)	16		
Soil Hydrocarbons	LA4-VW-20	LA4-MPA-7	LA4-MPA-35
TPH-D ^c (mg/kg)	430	60	27
TRPH ^d	1,580	41	ND (11)
Benzene (mg/kg)	ND (0.002)	ND (0.0003)	ND (0.0003)
Toluene (mg/kg)	ND (0.002)	ND (0.0003)	ND (0.0003)
Ethylbenzene (mg/kg)	ND (0.002)	ND (0.0003)	ND (0.0003)
Xylenes (mg/kg)	ND (0.004)	ND (0.0007)	ND (0.0007)
Soil Inorganics			
Iron (mg/kg)	6,100	12,100	8,600
Alkalinity (mg/kg as Ca CO ₃ ^e)	100	590 (540) ^f	620
pH (Units)	8.3	8.1 (8) ^f	9.8 (9.8) ^f
TKN ^g (mg/kg)	140	110	ND
Phosphates (mg/kg)	2,200	860	670
Soil Physical Parameters			
Moisture (% wt)	4.8	12	12
Gravel (%)	29.4	2.1	0.0
Sand (%)	61.1	74.1	93.1
Silt (%)	4.0	11.8	5.1
Clay (%)	5.5	12.1	1.8

^a ppmv = Parts Per Million, Volume Per Volume; mg/kg = Milligrams Per Kilogram

^b TVH = Total Volatile Hydrocarbons referenced to Jet Fuel (MW = 156).

^c TPH-D = Total Petroleum Hydrocarbons as Diesel by SW 8015 Modified.

^d TRPH = Total Recoverable Petroleum Hydrocarbons by EPA 418.1.

^e Ca CO₃ = Calcium Carbonate

^f Surrogate recovery outside established control limits.

^g TKN = Total Kjeldahl Nitrogen

NA = Not Analyzed.

ND = None Detected. Method detection limits are in parentheses.

Table 4.2
Initial Soil Gas Chemistry
Building 125 Former Heating Oil UST Site
Los Angeles AFB, California

Sample Location	Depth (ft bgs)	O ₂ (percent)	CO ₂ (percent)	TVH-Field (ppmv) ^a	TVH-Field (ppmv) ^b	TVH-Lab (mg/kg) ^c	Temperature °F
LA4-VW	7-37.5	0.0	6.0	> 20,000	2,000	2,200	NA
LA4-MPA-7	7	NS	NS	NS	NS	NS	80.6
LA4-MPA-20	20	0.0	11.2	> 20,000	1,400	NA	NA
LA4-MPA-35	35	0.0	10.8	> 20,000	3,000	NA	75.1

^a Total hydrocarbon analyzer field screening results.

^b Total hydrocarbon analyzer field screening results. No Methane Response.

^c Laboratory results referenced to Jet Fuel (MW = 156).

NA = Not Analyzed

NS = Not Sampled

Table 4.3
Oxygen Utilization Rates
Building 125 Former Heating Oil UST
Los Angeles AFB, California

MP	O ₂ Loss ^a (percent)	Test Duration (min.)	O ₂ Utilization ^a Rate (percent/min)	Hydrocarbon Degradation Rate (mg/kg/yr)
LA4-VW	20.5	3,200	0.0055	1,380

^a Values based on linear regression (Figure 4.6)

4.3.3 *In Situ* Respiration Rates

An *in situ* respiration test was conducted at the site according to protocol document procedures. Three 1 cfm pumps were used to inject air into LA4-VW for 19 hours. Helium, at a concentration of between 3 and 4 percent was also injected into the VW. Oxygen concentration in LA4-VW was increased to 20 percent. After air injection ceased, changes in soil gas composition were monitored over time. Oxygen, carbon dioxide, TVH, and helium concentrations were measured over a period of 53 hours following the air injection period. The observed rate of oxygen utilization was then used to estimate the aerobic fuel degradation rates at the site. Figure 4.6 presents the results of *in situ* respiration testing at the site, and Table 4.3 provides a summary of the observed oxygen utilization rate. The oxygen utilization rates observed in contaminated soils penetrated by LA4-VW was 0.0055 percent per minute (%/min), as shown in Table 4.3. Helium concentrations decreased by approximately 50 percent during the test indicating that a portion of the oxygen loss may have been due to diffusion. However, biodegradation appears to be the major contribution to oxygen loss.

An estimated 1,380 milligrams (mg) of fuel per kilogram (kg) of soil can be degraded each year. The fuel consumption rate was calculated using the observed oxygen utilization rate, an estimated air-filled porosity of 0.123 liters of air/kg of soil, and a conservative ratio of 3.5 mg of oxygen consumed for every 1 mg of fuel biodegraded. The oxygen utilization rates observed in contaminated soils penetrated by LA4-VW was 0.0055 percent per minute (%/min), as shown in Table 4.3.

4.3.4 Air Permeability

An air permeability test was conducted at the site according to protocol document procedures. Air was injected into the VW using a 1 horsepower blower for approximately 5 hours at a rate of approximately 73 cfm and an average pressure of approximately 11.5 inches of water. The pressure responses at MPA are listed in Table 4.4. The pressure measured at MPA continued to increase for the duration of the test. The dynamic method of determining air permeability is coded in the HyperVentilate® model that was used to calculate soil gas permeability values ranging from 83 darcys to 94 darcys for this site. A minimum radius of pressure influence of 10 feet was observed at all depths.

4.3.5 Oxygen Influence

The depth and radius of oxygen influence in the subsurface resulting from air injection into the central VW during pilot testing is the primary design parameter for a full-scale bioventing system. Optimization of full-scale and multiple VW systems requires pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration.

Table 4.5 describes the change in soil gas oxygen levels that occurred after 5 hours of air injection during the air permeability test at the site. This air injection period at 73 cfm produced changes in soil gas oxygen levels at a distance of at least 10 feet from the central VW at all depths in MPA. Based on measured pressure response, which is an indicator of long-term oxygen transport, it is anticipated that the radius of influence

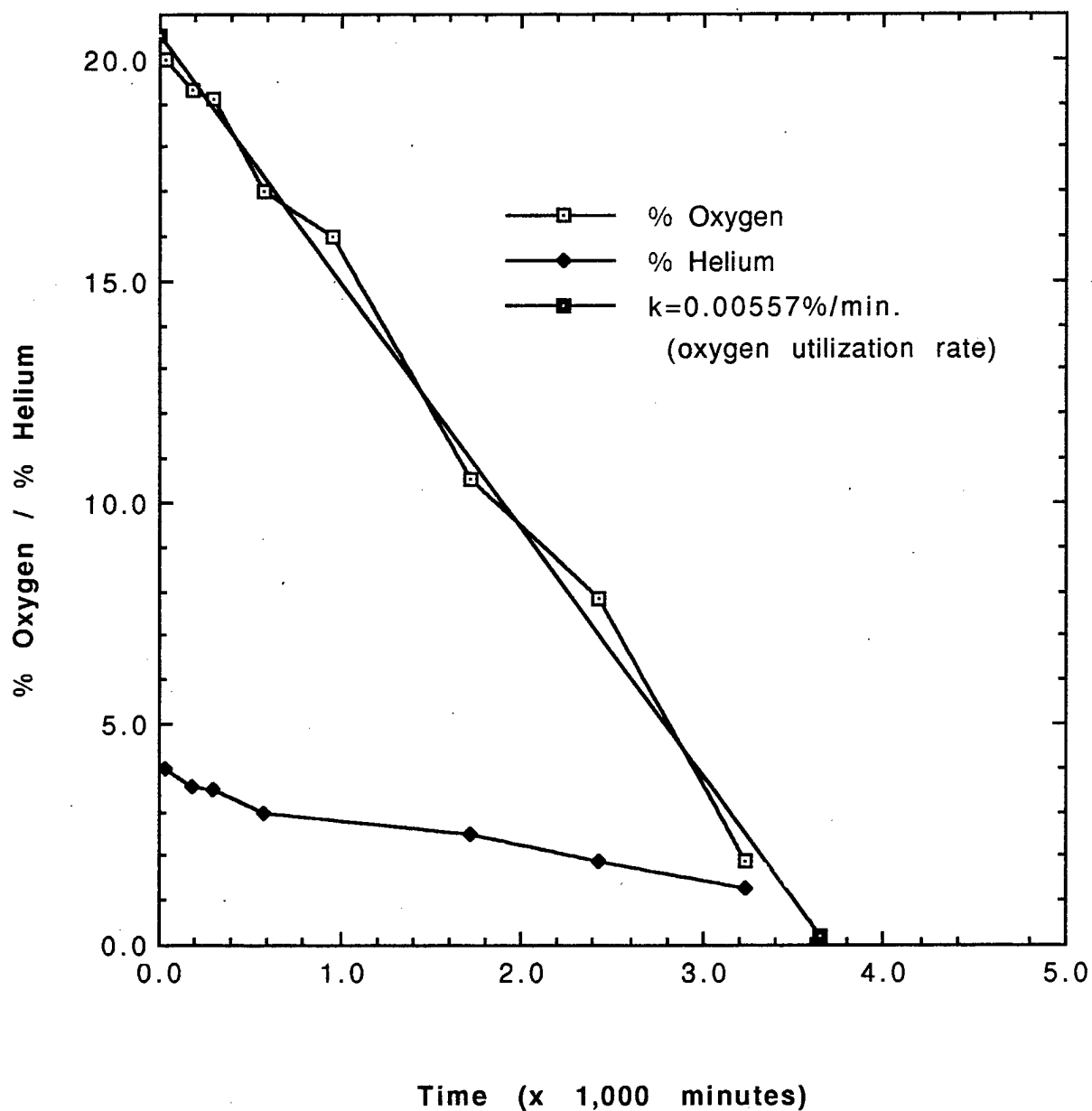


FIGURE 4.6
Respiration Test
LA4-VW
Building 125
Former Heating Oil UST Site

Engineering-Science, Inc.

ES

Table 4.4

Pressure Response (Inches of Water) During Air Permeability Test
Building 125 Former Heating Oil UST Site
Los Angeles AFB, California

<u>Location</u>				<u>Location</u>			
<u>MPA</u>				<u>MPA</u>			
Depth				Depth			
(ft. bgs)	7	20	35	(ft. bgs)	7	20	35
Elapsed time (min.)				Elapsed time (min.)			
0	0	0	0	(cont'd.)			
1	0	1.5	1.5	26	0.17	3.4	3.4
2	0	2.0	2.1	28	0.17	3.4	3.4
3				30	0.17	3.45	3.45
4	0.05	2.5	2.6	33	0.17	3.45	3.5
5	0.07	2.7	2.7	36	0.15	3.5	3.5
6	0.1	2.8	2.8	39	0.15	3.5	3.55
7	0.1	2.9	2.9	42	0.15	3.55	3.6
8	0.12	2.95	3.0	45	0.15	3.6	3.6
9	0.12	3.0	3.0	48	0.15	3.6	3.6
10	0.15	3.0	3.1	51	0.15	3.6	3.6
12	0.15	3.1	3.1	54	0.2	3.65	3.65
14	0.12	3.2	3.2	57	0.2	3.65	3.65
16	0.12	3.2	3.2	60	0.2	3.65	3.65
18	0.15	3.3	3.3	75	0.2	3.7	3.7
20	0.15	3.35	3.35	190	0.2	3.8	3.8
22	0.15	3.35	3.35	115	0.2	3.8	3.8
24	0.17	3.4	3.4	176	0.2	4.0	4.0

Table 4.5

**Influence of Air Injection Vent Well on Monitoring Point Oxygen Levels
Building 125 Former Heating Oil UST Site
Los Angeles AFB, California**

Location	Distance from VW (ft.)	Depth (ft. bgs)	Initial O ₂ (percent)	Final O ₂ ^a (percent)
LA4-MPA7	10	7	NS	NS
LA4-MPA 20	10	20	0.0	20.2
LA4-MPA 35	10	35	0.0	18.4

^a Readings taken after 5 hours of air injection during air permeability test.

for a long-term bioventing system at this site will exceed 10 feet and, should encompass all the soil contamination at the site.

4.3.6 Potential Air Emissions

Site contamination consists of heating oil, a compound of relatively low volatility. The maximum field head space reading observed at the site was 46.2 ppm. The maximum concentration of TVH and benzene compounds detected in soil gas samples was 2,200 ppmv and ND, respectively. Also, due to the presence of methane in the subsurface, and the relatively small amount of contaminated soil detected at the site, an air injection rate of 2.3 cfm is being used for the long-term test. The low flow rate will help prevent the unwanted migration of methane beneath buildings, as well as reduce the potential for volatile emissions. The long-term potential for air emissions from full-scale bioventing operations at this site is low. Initial emissions should be minimal because accumulated vapors will move slowly outward from the air injection point, and will be biodegraded as they move horizontally through the soil. During the air permeability test, air was injected at 73 cfm. Health and safety hydrocarbon-analyzer air monitoring of the breathing zone at the site indicated that total hydrocarbon concentrations did not increase above 1 ppmv during the initial days of the test. The initial day of bioventing generally produces the highest potential for emissions as the first pore volume of soil gas is replaced.

4.4 Recommendations

Initial bioventing tests at this site indicate that oxygen had been depleted in the contaminated soils, and that air injection is an effective method of stimulating aerobic fuel biodegradation. AFCEE has recommended that air injection continue at this site to determine the effects of time, available nutrients, and changing temperatures on fuel biodegradation rates.

A 2.3 cfm rotary vane blower has been installed at the site for continuous air injection. In May 1994, ES will return to the site to sample and analyze the soil gas and conduct a repeat respiration test. In December 1994, a final respiration test will be conducted, and soil and soil gas samples will be collected from the site to determine the degree of remediation achieved during the first year of *in situ* treatment.

5.0 REFERENCES

- Engineering-Science, Inc., 1992. *Field Sampling Plan for AFCEE Bioventing*, Denver, Colorado.
- Hinchee, R.E., Ong, S.K., Miller, R.N., Downey, D.C., Frandt, R., 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing*, January.
- Mittelhauser Corporation, 1992. U.S. Army Corps of Engineers, Los Angeles Air Force Base, UST Investigation Report, October.

APPENDIX A

APPENDIX A
O&M INSTRUCTIONS

**ROTARY VANE BLOWER
OPERATION AND MAINTENANCE MANUAL
FOR EXTENDED TESTING SYSTEM AT
LOS ANGELES AIR FORCE BASE,
BUILDING 125**

Prepared for:

**AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AFB, TEXAS**

USAF CONTRACT F33615-90-D-4010, DELIVERY ORDER 14

JANUARY 1994

Prepared by:

**Engineering-Science, Inc.
199 South Los Robles Avenue
Pasadena, California**

SECTION 1

INTRODUCTION

This document has been prepared by Engineering-Science, Inc. (ES), to support the bioventing initiative contract awarded by the Air Force Center for Environmental Excellence. This contract involves conducting bioventing pilot tests at thirty-five sites on twenty-three Air Force bases across the United States.

At most sites, bioventing systems will be installed upon completion of the bioventing pilot tests for the purpose of extended pilot testing. These systems will operate for a one-year period to provide further information as to the feasibility of this technology at each site, and to provide interim remedial action.

The Operation and Maintenance Manual has been created for sites at which blowers have been installed for extended pilot testing. Basic maintenance of these systems is the responsibility of the base. This manual is to be used by base personnel to guide and assist them in operating and maintaining the blower system. Section 2 provides a synopsis of the blower system configuration. Section 3 describes the blower. Section 4 details the maintenance requirements and provides maintenance schedules. Section 5 describes the system monitoring that is required to forecast system maintenance needs and provide data for the extended pilot test.

SECTION 2

BLOWER SYSTEM CONFIGURATION SUMMARY

System Type injection

Blower rotary vane

Blower Model Gast® model 2031-P101-G539X

Motor (Horsepower) 0.1

Knock-Out Chamber inlet and outlet (part number AA617G)

Sampling Port none

Inlet Temperature Gauge (range) not applicable

Inlet Vacuum Gauge (range) -30" - 0" Hg

Inlet Filter (part no.) B344A

Outlet Temperature Gauge (range) not applicable

Outlet Pressure Gauge (range) 0 - 30 PSI

Outlet Filter (part no.) B344A

Pressure/Vacuum Relief Valve Set at 8 PSI / 4" Hg

SECTION 3

BIOVENTING SYSTEM OPERATION

3.1 PRINCIPLE OF OPERATION

Bioventing is the forced injection of fresh air, or withdrawal of soil gas, to enhance the supply of oxygen for *in situ* bioremediation. Either a pressure (air injection) or vacuum (vapor extraction) blower unit is used to inject or withdraw air into or from the soil, thereby supplying fresh air with 20.8 percent oxygen to the contaminated soils. Once oxygen is provided to the subsurface, existing bacteria will proceed to breakdown the fuel residuals.

An injection blower system of the type described below has been installed at the Los Angeles Air Force Base Building 125 site.

3.2 SYSTEM DESCRIPTION

3.2.1 Blower System

A low flow, oilless, Gast® Series 2031, motor mounted, rotary vane blower powered by a 1/10 horsepower direct-drive motor was installed at Building 125. This blower is rated at a flow rate of 2.35 standard cubic feet per minute (scfm) at open flow; however, the actual performance of the blower will vary with changing site conditions. As installed at Building 125, the blower was producing an estimated flow rate of 2.0 scfm at a pressure of 8 PSI. The system includes air filters to remove any particulates which are entrained in the air stream, and several valves and monitoring gauges which are described in the next section. A schematic of the blower system installed at Building 125 is shown on the figure in Attachment A. Corresponding blower performance curves and relevant service information are also provided in Attachment A.

3.2.2 Monitoring Gauges

The bioventing system is equipped with vacuum and pressure gauges. A vacuum gauge has been installed on the air injection system at the blower inlet piping and a pressure gauge was installed on the blower outlet piping. See the figure in the attachment for the locations of the gauges installed on the blower systems.

SECTION 4.

SYSTEM MAINTENANCE

Although the motor and blower are relatively maintenance free, periodic system maintenance is required for proper operation and long life. Recommended maintenance procedures and schedules are described in detail in the instruction manuals included in Appendices A and B, and are briefly summarized in this section.

4.1 BLOWER AND MOTOR

The blower and motor are relatively maintenance free and should not require any periodic maintenance during the one-year extended testing period. Both blower and motor have sealed bearings and do not require lubrication.

4.2 AIR FILTER

To avoid damage caused by passing solids through the blower, an air filter has been installed in-line before the blower. This filter element is composed of felt. The filter should be checked weekly for the first two months of operation. A facility employee should determine the best schedule for filter replacement. If replacement filters are not immediately available, one may remove some of the solids accumulated on the filter element by using pressurized air or mechanical agitation. Filter elements may also be cleaned using a solvent (manufacturer recommends part number AH255). When the pressure or vacuum drop across the blower is above 10 PSI, a dirty filter element should be suspected, and cleaning or replacement should be performed.

Filter inspection must be performed with the system turned off. To remove the filter, unscrew the glass knockout jar and remove it, unscrew the plastic filter holder and remove, and slide the air filter off the end of the holder. When unscrewing the glass knockout jars, be careful that the rubber seals remain in place.

The filter element is manufactured by Gast® Manufacturing Corp. in Benton Harbor, Michigan. Their telephone number is (616) 926-6171. Additional filters can also be obtained through Engineering-Science, Inc., in Pasadena, California. The ES contact is Mr. Chris Pluhar. He can be reached at (818) 585-6324. The filter model number is B344A. It is recommended that at least one spare air filter be kept at the site; ten replacement filters were supplied with the blower system.

4.3 MAINTENANCE SCHEDULE

The following maintenance schedule is recommended for this system. The filter should be checked once per month and cleaned or replaced as necessary (see Section

5.2). During the initial months of operation, more frequent monitoring is recommended to ensure that any startup problems are quickly corrected. A daily drive-by inspection is recommended during the initial two weeks of operation to ensure that the blower system is still operating with no unusual sounds. Data collection sheets that can be used to record maintenance activities are included in Attachment B.

4.4 TROUBLESHOOTING

<u>Symptoms</u>	<u>Possible Diagnosis</u>	<u>Possible Remedy</u>
Excess Vibration	Vane damaged by foreign material. Vane contaminated by foreign material.	Replace vanes Clean vanes Flush blower Replace filters
Abnormal Sound	Motor bearing failed. Vane rubbing against cover or housing.	Replace bearings Repair blower Check clearances
Blown Fuse	Electrical wiring problem.	Have qualified person check fuse capacity and wiring.
Unit Very Hot	Running at too high a pressure/vacuum.	Install or adjust relief valves.

4.5 MAJOR REPAIRS

Blowers systems are very reliable when properly maintained. Occasionally, a motor or blower will develop a serious problem. If a blower system fails to start, and a qualified electrician verifies that power is available at the blower or starter, the ES Site Manager, Mr. Chris Pluhar, should be called at (818) 585-6324. ES is responsible for major repairs during the first year of operation.

SECTION 5

SYSTEM MONITORING

5.1 BLOWER PERFORMANCE MONITORING

To monitor the blower performance, vacuum and pressure will be measured. These data should be recorded weekly on a data collection sheet (provided in Attachment B). All measurements should be taken at the same time while the system is running. Because the system is loud, hearing protection should be worn at all times.

5.1.1 Vacuum/Pressure

With hearing protection in place, open the blower enclosure and record all vacuum and pressure readings directly from the gauges (in inches of mercury or Hg, or psi). Record the measurements on a data collection sheet (Attachment B).

5.1.2 Flow Rate

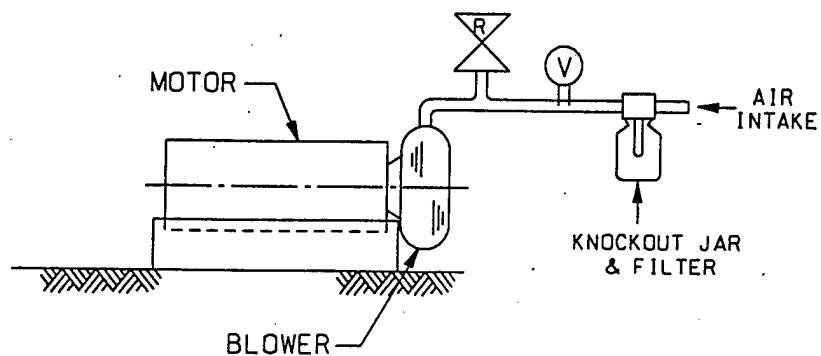
The flow rate through the vent well and soils can be calculated when the inlet vacuum and outlet pressure of the blower are known. This pressure change across the blower (vacuum + pressure) can be compared to the performance curves for the blower in Attachment A to determine the approximate flow rate. Note that the vacuum and pressure gauges use different units. These must be converted in order to get the correct flow rate. The conversion for inches of mercury to psi is: $\text{psi} = 0.5 \times \text{inches Hg}$.

5.3 MONITORING SCHEDULE

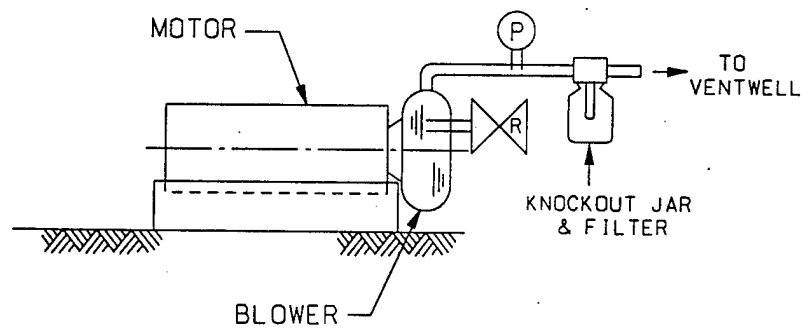
The following monitoring schedule is recommended for this system. During the initial months of operation, more frequent monitoring is recommended to ensure that any start up problems are quickly corrected. Data collection sheets have been provided to assist in data collection, and are included in Attachment B.

<u>Monitoring Item</u>	<u>Monitoring Frequency</u>
Vacuum/Pressure	Daily during first week, then once per week.
Temperature	Daily during first week, then once per week.

ATTACHMENT A






INLET SIDE



OUTLET SIDE

LEGEND

-  PRESSURE GAUGE (1/4" NPT)
 VACUUM GAUGE (1/4" NPT)
 PRESSURE OR VACUUM RELIEF VALVE

NOT TO SCALE

ROTARY VANE BLOWER
SYSTEM FOR AIR
INJECTION

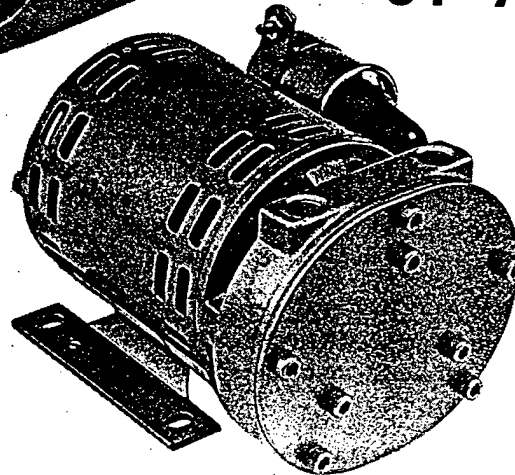
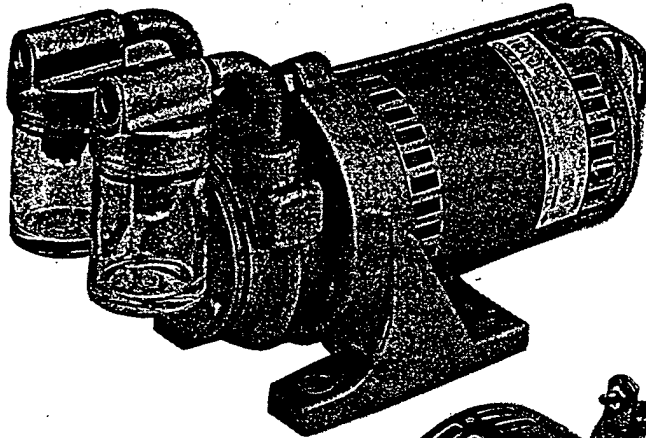
ENGINEERING-SCIENCE, INC.
Pasadena, California

ES




Post Office Box 97
Benton Harbor, MI. 49023
Ph: 616/926-6171
Fax: 616/925-8288

70-200/G330 3/93



OPERATING AND MAINTENANCE INSTRUCTIONS FOR MINIATURE ROTARY VANE PUMPS "31" AND "32" SERIES

Oilless Vacuum Pumps and Compressors

This is the hazard alert symbol.  When you see this symbol, be aware that personal injury or property damage is possible. The hazard is explained in the text following the symbol. Read the information carefully before proceeding.

The following is an explanation of the different types of hazards:

DANGER: Severe personal injury or death will occur if hazard is ignored.

WARNING: Severe personal injury or death can occur if hazard is ignored.

CAUTION: Minor injury or property damage will occur if hazard is ignored.



WARNING: Do Not Pump Flammable or Explosive Gases or
Operate in an Atmosphere that Contains Them.

Gast Authorized Service Facilities are Located at:

Gast Manufacturing Co. Ltd.
Halifax Road, Cressex Estate
High Wycombe, Bucks HP12 3SN
England
Ph: 44 494 523571
Fax: 44 494 436588

Gast Manufacturing Corporation
2550 Meadowbrook Road
Benton Harbor, MI. 49022
Ph: 616/926-6171
Fax: 616/925-8288

Gast Manufacturing Corporation
505 Washington Avenue
Carlstadt, N. J. 07072
Ph: 201/933-8484
Fax: 201/933-5545

Brenner Fiedler & Associates
13824 Bentley Place
Cerritos, CA. 90701
Ph: 310/404-2721
Ph: 800/843-5558
Fax: 310/404-7975

Wainbee Limited
5789 Coopers Ave.
Mississauga, Ontario
Canada L4Z 3S6
Ph: 416/213-7202
Fax: 416/213-7207

Wainbee Limited
215 Brunswick Blvd.
Pointe Claire, Quebec
Canada H9R 4R7
Ph: 514/697-8810
Fax: 514/-697-3070

Japan Machinery
Central PO Box 1451
Toyko 100-91, Japan
Ph: 813 3573-5421
Fax: 813 3571-7896

KEEP THIS DOCUMENT FOR FUTURE REFERENCE

Never lubricate this oilless air pump. The carbon vanes and grease packed motor bearings require no oil. The rotor is held in place with Loctite adhesive. **DO NOT REMOVE THE ROTOR.**

STARTING: If the motor fails to start, shut the motor off and unplug. If anything appears to be wrong with the motor, return the complete pump and motor assembly shell to an authorized service facility (addresses on front).

WARNING: THE MOTOR MAY BE THERMALLY PROTECTED AND WILL AUTOMATICALLY RE-START WHEN THE PROTECTOR RESETS. ALWAYS DISCONNECT POWER SOURCE BEFORE SERVICING.

FLUSHING: 32 series pumps cannot be flushed without disassembly. **WARNING - KEEP FACE AWAY FROM EXHAUST PORT AND DO NOT FLUSH UNIT WITH FLAMMABLE SOLVENT.** Flush unit in a well ventilated area. Should excessive dirt, foreign particles, moisture or oil be permitted to enter the pump, the vanes will act sluggish or even break. Flushing of the pump with Gast Flushing Solvent (Part #AH255) should take care of this condition. In order to flush a pump, remove the filter and introduce several teaspoons full of solvent into the pump through the intake WHILE THE PUMP IS RUNNING. Repeat the flushing procedure if it does not remedy the situation, remove the end plate for further examination.

FILTERS: Dirty filters restrict air flow and if not corrected could lead to possible motor overloading and early pump failure. Check filters periodically and clean when necessary by removing and washing in a solvent or soap and water. Filters are internal to the pump on 32 series units. Dry with compressed air and replace.

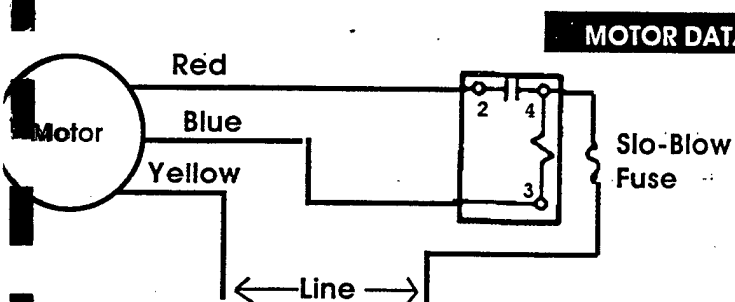
DISASSEMBLY: Remove the three screws which attach retainer plate to body. Now remove the retainer plate and carbon wear plate and you have access to the vanes. Use compressed air to clean out the pump chamber; especially if the vanes are broken. The carbon wear plates have two (2) usable sides. When one side is worn, simply flip it over. **DO NOT REMOVE THE ROTOR** since it is held in place by Loctite and can only be serviced by an authorized service facility. To reset clearance between top of rotor and top of bore of the body, just **LOOSEN** the screws that attach body to electric motor. **DO NOT REMOVE BODY** of pump because an exact factory determined body spacer gasket provides necessary clearance. After the screws are loosened, place a .001" feeler gauge between the top of the rotor and the body, holding the body in position while the body bolts are tightened. Withdraw the feeler gauge and rotate the rotor to be sure all points clear the bore. To prevent misalignment and damage to the pump **DO NOT LOOSEN OR ADJUST MOTOR THRU BOLTS.**

REASSEMBLY: Simply place carbon wear plate and retainer plate in position, add and tighten the end plate screws. Should the pump still fail to produce proper vacuum or pressure, send to authorized service center for repairs.

DANGER: TO PREVENT EXPLOSIVE HAZARD, DO NOT PUMP COMBUSTIBLE LIQUIDS OR VAPORS WITH THESE UNITS. PERSONAL INJURY AND/OR PROPERTY DAMAGE WILL RESULT.

Recommended solvent is Gast Flushing Solvent AH255. **DO NOT USE KEROSENE** or any other flammable solvents.

If units require more than installation of a service kit, it is usually quickest and less expensive to send the unit in for repair. All returns are F.O.B. to the service centers listed on the front of this document.



AC WIRING Diagram-Starter Relay

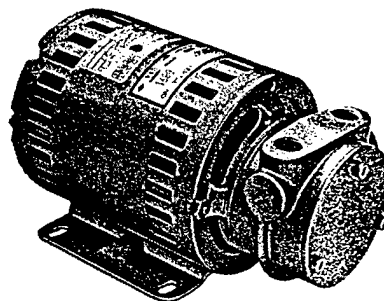
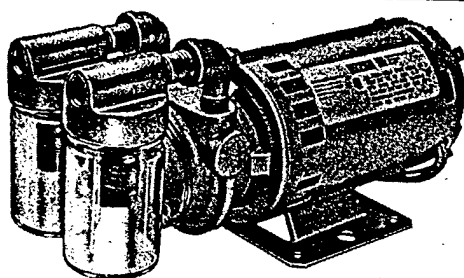
MOTOR DATA

BRUSHLESS DC UNITS with controls come pre-set from the factory for single direction, uni-speed operation. Red lead is positive (+) black lead is negative (-).

BRUSH-TYPE DC MOTORS will need replacement brushes after 500 to 1500 hours of operation. Contact your Gast distributor for brushes.

Model Number	Kit Number	Contents of Kit
0531	K259	Vanes, Cover Gaskets, Filter Felts
1031	K219	Vanes, Cover Gaskets, Filter Felts
1531	K219	Vanes, Cover Gaskets, Filter Felts
2031	K442	Vanes
3031	K447	Vanes
0532	K494	Vanes
1032	K497	Vanes
1532	K497	Vanes, Foams
2032	K442A	Vanes, Foams
3032	K554	Vanes, Foams

Oilless 2031, 2035, 3031 Series



MODEL 2031 SERIES

10 PSI MAX. PRESSURE, 2.35 CFM OPEN FLOW

MODEL 2035 SERIES

10 PSI MAX. PRESSURE, 2.4 CFM OPEN FLOW

MODEL 3031 SERIES

10 PSI MAX. PRESSURE, 2.7 CFM OPEN FLOW

PRODUCT FEATURES

- Oilless operation
- Motor mounted
- Rugged construction/low maintenance
- Essentially pulse-free service.

INCLUDES

- Muffler/Filter AA617G (2031)
- Thermotector
- Capacitor AG331, unattached (2035)
- Capacitor AF876, unattached (3031)

RECOMMENDED ACCESSORIES

- Pressure relief valve AA600
- Pressure gauge AA644B
- Repair kit K447 (2035 only)

COMMON MOTOR OPTIONS AVAILABLE

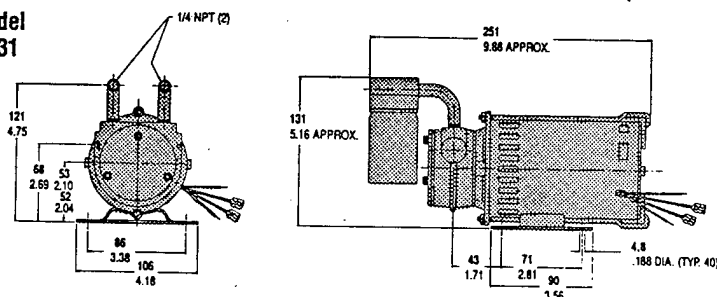
- 115V, 60 Hz, single phase
- 220/240V, 50 Hz, single phase
- 24V BLDC

Various brand name motors are used on any model at the discretion of Gast Mfg. Corp.

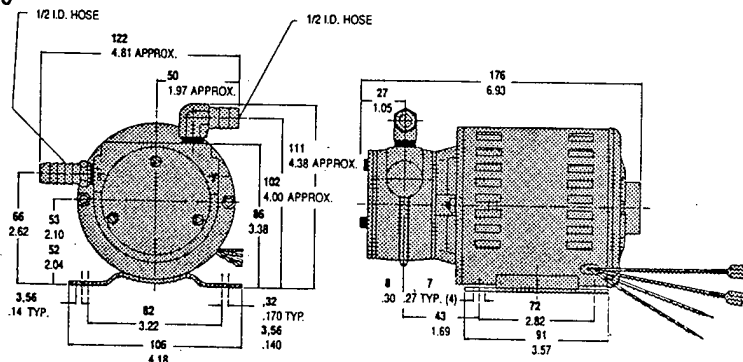
Important Notice:

Pictorial and dimensional data is subject to change without notice.

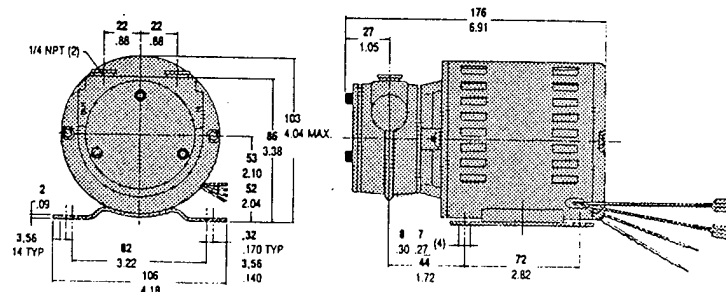
Model
2031



Model
2035



Model
3031

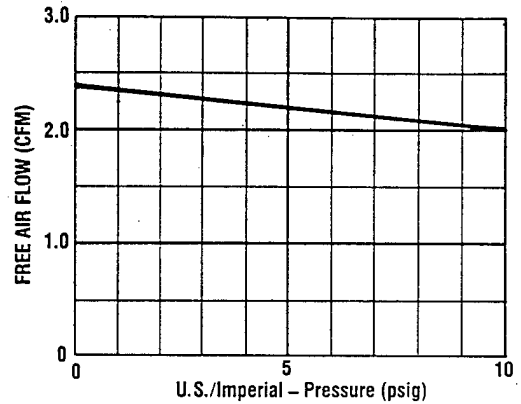
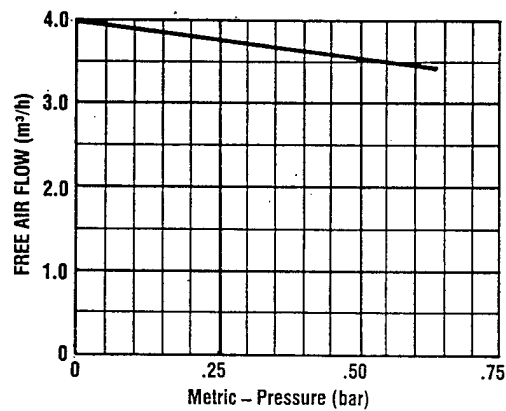


Product Specifications

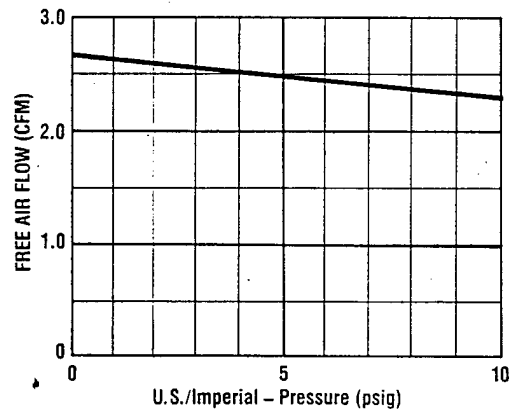
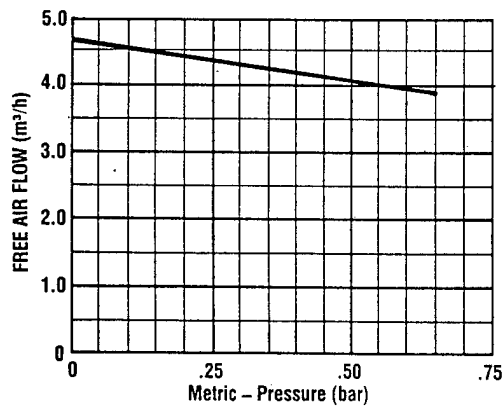
Model Number	Motor	RPM		HP	kW	Thermotector	Net Wt.	
		60 cycle	50 cycle				lbs.	kg
2031-P101-G539X	115-60-1	3450	—	1/10	0,07	■	9	4,09
2035-P102-G550X	220/240-50-1	—	2850	1/6	0,12	■	9	4,09
3031-P103-G556X	115-60-1	3450	—	1/10	0,07	■	9	4,09

Product Performance (Metric U.S. Imperial) Black line on curve is for 60 cycle performance.
Blue line on curve is for 50 cycle performance.

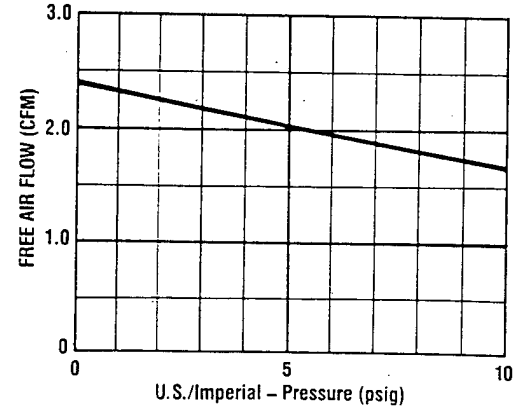
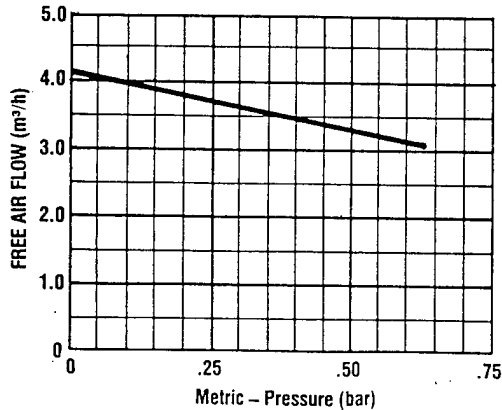
Model 2031



Model 2035



Model 3031



ATTACHMENT B

SITE: _____

[illegible]

APPENDIX B

APPENDIX B

GEOLOGIC LOGS AND CHAIN OF CUSTODY FORMS

430702.514

FE # 6485438810

430707.502

ENGINEERING SCIENCE INC
211.085870

450709.501

ENGINEERING-SCIENCE, INC.
211.0858/VO

430702.521

211.0858V0

430709.535

ENGINEERING SCIENCE INC
211.085870



AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

11325 SUNRISE GOLD CIRCLE, SUITE 'E'
RANCHO CORDOVA, CA 95742
(916) 638-9892 • FAX (916) 638-9917

CHAIN OF CUSTODY RECORD

Page 1 of 1

PROJECT # DE268.25.04 PO # DE 268.25.08 COLLECTED BY (Signature) Chad G. Phillips
REMARKS LA Air Ctlr Los Angeles AFB, CA 91781-241

FIELD SAMPLE I.D.#	SAMPLING MEDIA (Tenax, Canister etc.)	DATE/TIME	ANALYSIS	VAC./PRESSURE	LAB I.D.#
LA2-VW	Summa Canister	7/9/93 17:55	TO-3 (EPA), methanol STEX & TPH (asbestos, oil)		
LA2-MPA-20'	Summa Canister	7/9/93 18:05	TO-3 (EPA), methanol STEX & TPH (asbestos, oil)		
LA2-MPB-30'	Summa Canister	7/9/93 18:20	TO-3 (EPA), methanol STEX & TPH (asbestos, oil)		

RELINQUISHED BY: DATE/TIME Chad G. Phillips 7/9/93 18:50 RECEIVED BY: DATE/TIME Paul E. A. Bill # 6138247021

LAB USE ONLY

SHIPPER NAME LA Air Ctlr AIR BILL # 1 OPENED BY: DATE/TIME 1 TEMP (°C) 1 CONDITION 1

REMARKS 1



AIR TOXICS LTD.
AN ENVIRONMENTAL ANALYTICAL LABORATORY

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630
(916) 985-1000 • FAX (916) 985-1020

CHAIN OF CUSTODY RECORD

Page 1 of 1

PROJECT # DE 268.25.08 PO # Same COLLECTED BY (Signature) Cheryl G. Phillips
REMARKS Los Angeles AFB BioVenting (AFCEE contract)
Background monitoring points

FIELD SAMPLE I.D.#	SAMPLING MEDIA (Tenax, Canister etc.)	DATE/TIME	ANALYSIS	VAC./PRESSURE	LAB I.D.#
01A	LA BG-25' Summa canister	11/18/93 12:50	TO-3 (EPA) STEX & TPH	0.14g	
02A	LA BG-40' Summa canister	11/18/93 12:40	TO-3 (EPA) STEX & TPH	0.14g	

RELINQUISHED BY: DATE/TIME Cheryl G. Phillips 11/19/93 15:00 RECEIVED BY: DATE/TIME Let. Driscoll 11/22/93 10:00
FEDEX Air bill # 8238792811

LAB USE ONLY

SHIPPER NAME Los Angeles AFB AIR BILL # 8238792811 OPENED BY: DATE/TIME Let. Driscoll 11/22/93 10:00 TEMP (°C) 10.0 CONDITION Good

REMARKS Background monitoring points



AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

11325 SUNRISE GOLD CIRCLE, SUITE 'E'
RANCHO CORDOVA, CA 95742
(916) 638-9892 • FAX (916) 638-9917

CHAIN OF CUSTODY RECORD

PROJECT # DE268.25.04 PO # DE268.25.08 Page 1 of 1
REMARKS Los Angeles AFB Bio Venting Pilot Test LA3 (Gate 3) COLLECTED BY (Signature) Chitt-9 / J-P
LA4 (Bldg 125)

FIELD SAMPLE I.D.#	SAMPLING MEDIA (Tenax, Canister etc.)	DATE/TIME	ANALYSIS	VAC./PRESSURE	LAB I.D. #
01A LA4-VW	Summa Canister	7/11/93 10:20	BTEX, TVH(JP4), methane	0.5 Hg	
02A LA3-MPA-30'		7/13/93 10:40		1.0 Hg	
03A LA3-MPA-55'		7/13/93 10:39		1.0 Hg	
04A LA3-MPB-40'		7/13/93 10:55		1.0 Hg	

RELINQUISHED BY: DATE/TIME Chitt-9 7/13/93 14:30 RECEIVED BY: DATE/TIME 7/14/93 0945
Fed Ex Airbill # 7505350031

LAB USE ONLY

SHIPPER NAME LA3 AIR BILL # 7505350031 OPENED BY: DATE/TIME 7/14/93 0945 TEMP(°C) 24 CONDITION 7/14/93 0945

REMARKS LA3

Blows/Ft	PID (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
			5			
15/20/28	2.4*	100	10			SAND: pale brown (10 YR 6/3), medium; no odor, moist.
	3.5*		15			SAND: as above.
	3.1*		20			SAND: brown (10 YR 5/3), medium to coarse; no odor, moist.
20/50/50	3.7*	66	25			SAND: as above.
			30			SAND: as above.
	4.8*		35			SAND: pale brown (10 YR 6/3), medium; no odor, moist.
4/6/12	2.8*		40			Per driller: CLAY @ 38'. CLAY: olive (5 Y 5/3) laminated in parts with some medium grained sand lenses.
			45			Total depth of boring = 40' bgs. No groundwater encountered during drilling.

* Background PID reading = 1.5 ppm.

PROJECT	Los Angeles Air Force Base	DRILLING COMPANY	Tonto Drilling Services, Inc.
LOCATION	West of Day Care Center	DATE DRILLED	07/09/93
JOB NUMBER	DE268.25.04	SURFACE ELEVATION	
GEOLOGIST	Larry Dudus/Chris Pluhar	TOTAL DEPTH OF HOLE	40 Feet
DRILL RIG	Hollow Stem Auger	WATER LEVEL	

Blows/Ft	PID (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
			5			SILT, SAND, and CLAY: dark brown (10 YR 4/3); wet, plastic (fill).
	25		10			SILTY CLAY: black (10 YR 2/1), very strong petroleum odor (fill).
	120		15			Per driller: sand @ 14'. SAND: very dark gray (10 YR 3/1 to 10 YR 2/1), medium, very strong petroleum odor.
20/26/40		LA2-MPA-20	20	☒		SAND, as above, wet with product.
			25			SAND, as above, wet with product.
			30			SAND, as above, wet with product.
			35			SAND, as above, wet with product; per driller - no clay.
18/36/40	138		40			SAND, as above.
			45			SAND, as above.
	120		50			SAND, as above.
			55			Total depth of boring = 50' bgs. No groundwater encountered during drilling.

PROJECT	Los Angeles Air Force Base	DRILLING COMPANY	Tonto Drilling Services, Inc.
LOCATION	Building 241	DATE DRILLED	07/01/93
JOB NUMBER	DE268.25.04	SURFACE ELEVATION	
GEOLOGIST	Larry Dudus/Chris Pluhar	TOTAL DEPTH OF HOLE	50 Feet
DRILL RIG	Hollow Stem Auger	WATER LEVEL	

Blows/Ft.	PID (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
			5			
10/13/16	ND	100	10			SILT: brown (10 YR 4/3), some fine sand, some clay, moist, no odor.
						@ 13': Petroleum odor.
	60		15			SAND: black (10 YR 2/1), medium, strong petroleum odor, moist with product.
12/20/34	47	100	20			SAND: as above.
	51		25			SAND, as above; color changes to gray at approximately 26' bgs.
	40		30			SAND: very dark gray (10 YR 3/1); strong petroleum odor with slight sewage-like odor.
25/50-5"	80	66	35			SAND: black (10 YR 2/1), medium; moist with product, very strong petroleum odor.
14/18/26	0*	100 LA2-MPB-40	40	☒		CLAY: dark yellowish brown, light gray, and dark grayish brown; dry; fractures filled with black product, moderate petroleum odor.
55/60-6"	6	66	45			SAND: light yellowish brown (10 YR 6/4), medium, very slightly damp; no odor, no staining.
						Total depth of boring = 45' bgs. No groundwater encountered during drilling.
			50			

* PID reading from split spoon sampler. Possibly lower than standard field headspace reading.

PROJECT	Los Angeles Air Force Base	DRILLING COMPANY	Tonto Drilling Services, Inc.
LOCATION	Building 241	DATE DRILLED	07/02/93
JOB NUMBER	DE268.25.04	SURFACE ELEVATION	
GEOLOGIST	Larry Dudus/Chris Pluhar	TOTAL DEPTH OF HOLE	45 Feet
DRILL RIG	Hollow Stem Auger	WATER LEVEL	

Blows/Ft	PID (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
	0		5			SILT and CLAY: dark brown (10 YR 5/3); moist, plastic, no odor.
9/12/12	2.2	100	10			SILT: dark brown (10 YR 5/3), damp, non-plastic, some clay, no odor.
	0		15			SAND: yellowish brown (10 YR 5/4), medium, damp, no odor.
12/22/32	1.5*	100 LA2-MPC-20	20	☒		SAND: as above.
	0		25			SAND, as above.
32/50	2	66	30			SAND: as above.
9/18/20			35			SAND: as above.
			40			CLAY: black in fractures, no odor.
			45			SAND: yellowish brown (10 YR 5/4), medium, damp, no odor.
			50			Total depth of boring = 45' bgs. No groundwater encountered during drilling.
						* PID reading from split spoon sampler. Possibly lower than standard field headspace reading.

PROJECT	Los Angeles Air Force Base	DRILLING COMPANY	Tonto Drilling Services, Inc.
LOCATION	Building 241	DATE DRILLED	07/02/93
JOB NUMBER	DE268.25.04	SURFACE ELEVATION	
GEOLOGIST	Larry Dudus/Chris Pluhar	TOTAL DEPTH OF HOLE	45 Feet
DRILL RIG	Hollow Stem Auger	WATER LEVEL	

Blows/Ft	PID (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
						SILT, SAND, and CLAY: wet, plastic, no odor (fill).
2/2/3	0*	0	5			
						SILT, SAND, and CLAY: dark brown (10 YR 4/3); very wet, very plastic (fill).
5/6/11	60*	100 LA2-VW-10	10	⊗		
						SILT AND CLAY: brown, dark brown, and black (10 YR 5/3, 3/3, 2/1); wet, strong petroleum odor in black, wet clay. Odor decreases with depth (fill).
12/15/16	52*	100 LA2-VW-15	15	⊗		
						SAND: very dark gray to black (10 YR 3/1 to 2/1); medium, wet with product, very strong petroleum odor.
15/32/40	150	100	20			SAND, as above.
18/24/36	120	100	25			SAND: dark brown (10 YR 4/3); medium, very strong petroleum odor; wet with product.
30/60-6"	125	66	30			SAND, as above.
30/55-6"	120	66	35			SAND, as above, with some silt.
						Per driller: clay @ 38'.
12/23/34	0*	100	40			CLAY: dark yellowish brown, light gray, and dark grayish brown; dry, fractures filled with black product; moderate petroleum odor.
						Per driller: sand @ 43'.
40/50-5"	7.4		45			SAND: light yellowish brown (10 YR 6/4); medium, very slightly damp, no odor.
						Total depth of boring = 45' bgs. No groundwater encountered during drilling.
						* PID reading from split spoon sampler. Possibly lower than standard field headspace reading.

PROJECT Los Angeles Air Force Base

LOCATION Building 241

JOB NUMBER DE268.25.04

GEOLOGIST Larry Dudus/Chris Pluhar

DRILL RIG Hollow Stem Auger

DRILLING COMPANY Tonto Drilling Services, Inc.

DATE DRILLED 07/01/93

SURFACE ELEVATION

TOTAL DEPTH OF HOLE 45 Feet

WATER LEVEL

Blows/Ft	PID (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
10/16/16	14.2	100	5			CLAY: very dark grayish brown (10 YR 3/2); some fine to coarse grained sand; moist, no odor (fill).
9/10/18	11.3	100	10			CLAY: as above (fill).
12/16/30	30.4	100	15			SAND: brown (10 YR 5/3), medium grained; slightly damp, moderate petroleum odor, and clay as above (fill).
12/15/18	0*	100 LA3-MPA-20	20	8		SAND: yellowish brown (10 YR 5/4), fine to medium grained, moderate petroleum odor.
4/4/5	89.9	100	25			SAND: yellowish brown (10 YR 5/4), medium grained, moderate to strong petroleum odor.
18/60	196	70	30			SAND: light brownish gray (2.5 Y 6/2), medium grained; moderate to strong petroleum odor.
30/50-4"	257	60	35			SAND: gray (5 Y 5/1), medium to coarse grained; very slightly damp, strong petroleum odor.
8/20/30	320	100	40			CLAY: dark yellowish brown (10 YR 4/4), moist, some silt, some medium grained sand; very strong petroleum odor.
18/24/28	0*	100 LA3-MPA-45	45	8		SAND: brown (10 YR 5/3), fine to medium grained; very slightly damp, very slight petroleum odor.
30/50-5"	27	100	50			SAND: grayish brown (10 YR 5/2), medium to coarse grained; moist, slight petroleum odor.
12/14/30	0	100	55			CLAY: light olive brown (2.5 Y 5/3); bottom 3" very dark gray (2.5 Y N/3); moist, very plastic, no odor. Dark gray clay is micaceous.
24/55		66	60			CLAY: dark grayish brown (2.5 Y 4/2), some medium grained sand; very micaceous, non-plastic, no odor.
			65			Total depth of boring = 60' bgs. No groundwater encountered during drilling.
			70			* PID reading from split spoon sample. Possibly lower than standard field headspace reading.

PROJECT Los Angeles Air Force Base

LOCATION Gate 3 at Area A

JOB NUMBER DE268.25.04

GEOLOGIST Larry Dudus/Chris Pluhar

DRILL RIG Hollow Stem Auger

DRILLING COMPANY Tonto Drilling Services, Inc.

DATE DRILLED 07/06/93

SURFACE ELEVATION

TOTAL DEPTH OF HOLE 60 Feet

WATER LEVEL

Blows/Ft	PID (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
			5			CLAY: very dark grayish brown (10 YR 4/3); some fine to coarse sand; moderately plastic, moist, no odor (fill).
	0		10			CLAY: as above (fill).
	0.3		15			CLAY: as above (fill).
11/8	6.5	100	20			SAND: brown (10 YR 4/3), medium; very slightly damp, very slight petroleum odor.
	3.5		25			SAND: as above.
22/38	11.3	100	30			SAND: grayish brown (10 YR 5/2), medium; very slightly damp, very slight petroleum odor.
	8.5		35			SAND: as above, slight petroleum odor.
5/6	250	100	40			CLAY: dark grayish brown (2.5 Y 4/2), little sand, medium to coarse; moist, plastic, very strong petroleum odor.
	III		45			SAND: grayish brown (2.5 Y 5/2), medium; slightly damp, strong petroleum odor.
	7.1		50			SAND: brown (10 YR 5/3), medium; very slightly damp, strong petroleum odor.
8/0	8.4	100	55			CLAY: light olive brown (2.5 Y 5/3); micaceous, plastic, slightly moist, no odor.
			60			Total depth of boring = 59' bgs. No groundwater encountered during drilling.

PROJECT Los Angeles Air Force Base

DRILLING COMPANY Tonto Drilling Services, Inc.

LOCATION Gate 3 at Area A

DATE DRILLED 07/06/93

JOB NUMBER DE268.25.04

SURFACE ELEVATION _____

GEOLOGIST Larry Dudas/Chris Pluhar

TOTAL DEPTH OF HOLE 59 Feet

DRILL RIG Hollow Stem Auger

WATER LEVEL _____

Blows/Ft	PID (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
			5			CLAY: very dark grayish brown (10 YR 3/2); plastic, some fine to coarse sand; moist, no odor (fill).
	12.5		10			CLAY: as above, with some sand (fill).
	17		15			SAND: dark yellowish brown, medium, little clay chunks, moist, no odor (fill).
17/23	39	66	20			SAND: grayish brown (10 YR 5/2), medium; very slightly damp, no odor.
	21		25			SAND: as above.
16/38	23	66	30			SAND: pale brown (10 YR 6/3), fine to medium; very slightly damp, no odor.
	20		35			SAND: yellowish brown (10 YR 5/4), fine to medium; very slightly damp, no odor.
4/8	2.1	66	40			CLAY: light olive brown (2.5 Y 5/3) and reddish brown (5 YR 4/4); iron staining, plastic, moist, no odor.
	19.8		45			SAND: brown (10 YR 4/3), medium to coarse.
	10.1		50			SAND: olive brown (2.5 Y 4/4), medium; very slightly damp, no odor.
6/8	19.1	66	55			CLAY: olive brown (2.5 Y 4/3) and very dark gray (10 YR 3/1); plastic, moist, no odor.
			60			Total depth of boring = 59' bgs. No groundwater encountered during drilling.

PROJECT	Los Angeles Air Force Base	DRILLING COMPANY	Tonto Drilling Services, Inc.
LOCATION	Gate 3 at Area A	DATE DRILLED	07/06/93
JOB NUMBER	DE268.25.04	SURFACE ELEVATION	
GEOLOGIST	Larry Dudus/Chris Pluhar	TOTAL DEPTH OF HOLE	59 Feet
DRILL RIG	Hollow Stem Auger	WATER LEVEL	

Blows/Ft	PID (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
			5			CLAY: very dark grayish brown (10 YR 3/2); some fine to coarse sand; no odor (fill).
			10			Same as above (fill).
4/6/8	39	100	15			SAND: light olive brown (2.5 Y 5/3), medium; some clay chunks as above (fill), moderate petroleum odor.
	265		20			SAND: light olive brown (2.5 Y 5/3), medium; moderate to strong petroleum odor.
26/50	264	66	25			SAND: as above, strong petroleum odor.
20/60/ 50-4"	97*	90 LA3-VW-30	30	⊗		SAND: light olive brown (2.5 Y 5/3), medium; strong petroleum odor.
	208		35			SAND: gray (5 Y 5/1), medium; damp, strong petroleum odor.
7/7/8	167*	100 LA3-VW-40	40	⊗		CLAY: olive brown (2.5 Y 4/3); moist, plastic, micaceous; some fine sand and silt; very strong petroleum odor.
	297		45			SAND: dark yellowish brown (10 YR 4/4), medium; strong petroleum odor.
27/50-5"	220	50	50			SAND: grayish brown (10 YR 5/2), medium to coarse; damp, very strong petroleum odor.
13/15/24	1	100 LA3-VW-55	55	⊗		CLAY: brown (10 YR 4/3); micaceous, moderately plastic, very slight petroleum odor; minor iron staining.
			60			Total depth of boring = 59' bgs. No groundwater encountered during drilling.
			65			* PID reading from split spoon sample. Possibly lower than standard field headspace reading.

PROJECT	Los Angeles Air Force Base	DRILLING COMPANY	Tonto Drilling Services, Inc.
LOCATION	Gate 3 at Area A	DATE DRILLED	07/06/93
JOB NUMBER	DE268.25.04	SURFACE ELEVATION	
GEOLOGIST	Larry Dudus/Chris Pluhar	TOTAL DEPTH OF HOLE	59 Feet
DRILL RIG	Hollow Stem Auger	WATER LEVEL	

Blows/Ft	PTD (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
4/4/7	0	100 LA4-MPA-7	5	☒		SAND: dark yellowish brown (10 YR 4/4), medium to coarse; moist to wet, no odor.
			10			CONCRETE @ 10': 8" thick, former tank slab.
8/10/14	0	100	15			SAND: dark brown (7.5 YR 4/4), medium; damp, no odor.
	0		20			SAND: as above.
20/30/40	0	100	25			SAND: yellowish brown (10 YR 5/4), medium; very slightly damp, no odor.
	0		30			SAND: as above.
28/40/40	0	60 LA4-MPA-35	35	☒		SAND: as above.
			40			CLAY: dark brown (2.5 YR 6/5), non plastic, red staining, very slightly damp, no odor.
			45			Total depth of boring = 40' bgs. No groundwater encountered during drilling.

PROJECT Los Angeles Air Force Base

LOCATION Building 125

JOB NUMBER DE268.25.04

GEOLOGIST Larry Dudas/Chris Pluhar

DRILL RIG Hollow Stem Auger

DRILLING COMPANY Tonto Drilling Services, Inc.

DATE DRILLED 07/08/93

SURFACE ELEVATION _____

TOTAL DEPTH OF HOLE 40 Feet

WATER LEVEL _____

Blows/Ft	PID (ppm)	Recov./I.D.	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
5/5/8	3.6	100	5			SAND: brown (10 YR 4/3), medium; moist, slight petroleum odor (fill).
6/10	46.2	66	10		+++	CONCRETE @ 10': 8" thick, former tank slab SAND: very dark gray (10 YR 3/1), medium; moist, strong petroleum odor (fill).
13/8/10	29	100	15			SAND: dark grayish brown (10 YR 4/2), medium; damp, slight petroleum odor.
8/10/20	12.0*	100 LA4-VW-20	20	☒		SAND: grayish brown (10 YR 5/2), medium; very slightly damp, slight petroleum odor.
15/36/50	31	100 LA4-VW-25	25	☒		SAND: as above.
28/55	78	60	30			SAND: grayish brown (10 YR 5/2), medium; slightly damp, slight petroleum odor.
						@ 33': Possible clay layer, 1' to 18" thick
50/80	11.4	60	35			SAND: yellowish brown (10 YR 5/4), medium; slightly damp, slight petroleum odor.
						CLAY: dark brown (7.5 YR 4/4) and red (2.5 YR 6/5); non plastic, friable, very slightly damp, no odor.
10/12/17	0	100	40			Total depth of boring = 40' bgs. No groundwater encountered during drilling.
			45			* PID reading from split spoon sample. Possibly lower than standard field headspace reading.

PROJECT Los Angeles Air Force Base

DRILLING COMPANY Tonto Drilling Services, Inc.

LOCATION Building 125

DATE DRILLED 07/08/93

JOB NUMBER DE268.25.04

SURFACE ELEVATION _____

GEOLOGIST Larry Dudas/Chris Pluhar

TOTAL DEPTH OF HOLE 40 Feet

DRILL RIG Hollow Stem Auger

WATER LEVEL _____